AN EXAMINATION OF THE VARIATION IN INFORMATION SYSTEMS PROJECT COST ESTIMATES: THE CASE OF YEAR 2000 COMPLIANCE PROJECTS

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The year 2000 (Y2K) problem presented a fortuitous opportunity to explore the relationship between estimated costs of software projects and five cost influence dimensions described by the Year 2000 Enterprise Cost Model (Kappelman, et al., 1998) -- organization, problem, solution, resources, and stage of completion. This research was a field study survey of (Y2K) project managers in industry, government, and education and part of a joint project that began in 1996 between the University of North Texas and the Y2K Working Group of the Society for Information Management (SIM).

Evidence was found to support relationships between estimated costs and organization, problem, resources, and project stage but not for the solution dimension. Project stage appears to moderate the relationships for organization, particularly IS practices, and resources. A history of superior IS practices appears to mean lower estimated costs, especially for projects in larger IS organizations. Acquiring resources, especially external skills, appears to increase costs. Moreover, projects apparently have many individual differences, many related to size and to project stage, and their influences on costs appear to be at the sub-dimension or even the

individual variable level. A Revised Year 2000 Enterprise Model is presented incorporating this granularity.

Two primary conclusions can be drawn from this research: (1) large software projects are very complex and thus cost estimating is also; and (2) the devil of cost estimating is in the details of knowing which of the many possible variables are the important ones for each particular enterprise and project. This points to the importance of organizations keeping software project metrics and the historical calibration of cost-estimating practices. Project managers must understand the relevant details and their interaction and importance in order to successfully develop a cost estimate for a particular project, even when rational cost models are used. This research also indicates that software cost estimating has political as well as rational influences at play.

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CHAPTER 1

PROBLEM STATEMENT

Introduction

Software development and maintenance is a big investment for most organizations today, requiring management to carefully consider costs and benefits before committing resources to any potential software project. Organizations have to predict the lifetime benefits of information system (IS) projects, estimate their development and ongoing costs, and make decisions about the economic value of these projects to determine whether or not they will be undertaken. Cost estimates are important for determining staffing levels and for controlling implementation of software development projects as well as for selection and scheduling of projects initially. Thus, accurate prediction of benefits and costs is crucial in a software development project's evaluation since it can have a direct and significant impact on the quality and return of an organization's investment decisions.

The Problems in Estimating Software Project Costs

Both overestimation and underestimation of costs for information system projects can alter the perceived benefit of a project for an organization and consequently the determination of whether a project will be undertaken. When costs are underestimated, projects are initiated with an inflated impression of their worth and may subsequently prove to be poor investments, even when originally thought to have significant value. Cost creep (an increase in estimated and/or actual costs as projects progress toward completion) is common in software development projects but particularly for large, complex projects. In fact, more than half of all large, complex projects significantly exceed estimated costs (Jones, 1996a, 1996b; Lederer & Prasad, 1992a, 1992b; Yourdon, 1997). Many projects are therefore eventually canceled due to inaccurate cost estimates that caused overruns of both time and money. Yourdon (1997) reports that 15% of all software projects are delayed and 25% are canceled before completion.

Historically, underestimation of software project costs has resulted in low credibility for the cost estimates given by IS managers, especially for early cost estimates (Kusters, van Genuchten, & Heemstra, 1990; Lederer & Prasad, 1992a). Although it is recommended that project managers delay estimating costs until after a proposed project has been thoroughly analyzed in order to improve accuracy (Lederer & Prasad, 1992a; Cohn, 1996), it is often necessary for managers to provide cost estimates early. Cost estimates are necessary in order to assess the value of an IS project to an organization and to determine whether the project will proceed. However, even when early estimates are presented as “preliminary” or “ballpark” figures, managers are often held accountable for the early estimates, particularly when costs increase.

Many projects are abandoned when their costs are greatly underestimated, resulting in their total loss to the enterprise. More often, though, underestimated projects are completed but released prematurely to meet the projected budget, resulting in systems that are incomplete and unreliable (Kemerer, 1993; Littlewood, 1987). As a consequence these projects, even when delivered within budget, do not have the value that the organization originally anticipated.

The importance of accurate cost estimates to the success of IS projects is reflected in research concerning project failures. The Standish Group International Inc. has studied IS project failures and reports the following (Field, 1997):

1. Forty percent of IT application development projects are canceled before completion.

2. Thirty-three percent of the remaining projects are challenged by cost/time overruns or changes in scope.

3. Together, failed or challenged projects cost U.S. companies and government $145 billion per year.

Two primary factors cause IS projects to not be completed within their estimated cost: (1) inaccuracies in the estimation process itself and (2) failure of IS project managers to implement projects successfully within the estimated budget. Even though an estimate's accuracy is unknown until the project is completed, both the quality of the estimate and the quality of the IS project effort determine the proximity of the actual final cost and the estimate. Therefore, the cost-estimating process and the project-management process of IS development and maintenance projects are dependent and inseparable. Because cost estimation is used to schedule resources and to control project implementation as well as to predict economic value, there is growing interest in improving the accuracy and reliability of estimating costs for software development projects (Lederer & Prasad, 1992a, 1992b; Cash, 1997; Raja, 1985).

While underestimation is the more severe of the two types of estimation errors, project overestimation may actually increase project cost by putting less pressure on IS staff (Abdel-Hamid & Madnick, 1987) to be productive or by adding additional and perhaps superfluous system features. Another pitfall of overestimation is the unnecessary rejection of a project based on the cost/benefit analysis, which results in a missed opportunity to create value for the organization.

In summary, both overestimation and underestimation of software project costs can result in costly errors. Therefore, more accurate IS project estimation can reduce unnecessary costs and increase the organization's effectiveness and efficiency in utilizing its IS assets.

Due to the aforementioned concerns, this research proposes to identify the factors that influence the estimated cost of IS development and maintenance projects. It was prompted by two important factors: (1) the growing importance of accurately estimating the cost of IS projects -- particularly large, complex ones, and (2) the need for project managers to have as much information and insight as possible in order to manage these software projects.

Definition of Software Project Cost Estimation

Before undertaking a further discussion of software project cost estimation, the term must be defined. Generally speaking a software project cost estimate, consists of (Giles & Barney, 1995):

1. Estimating the effort (i.e., labor hours) needed to complete a project.
2. Estimating the elapsed time and the resources required for the project
3. Estimating the labor and resource costs of the project.

What is known or what can be determined about the proposed project largely drives the estimates for these components. Project data or attributes fall into three categories: (1) the parameters that describe the proposed project, (2) the characteristics of the group that will do the work, and (3) the process and required resources that will produce the product.

Estimating costs for an IS development or maintenance project is a process rather than a one-time event. The process of predicting the unknown quantity, cost, from a set of project attributes is twofold. It is necessary to first define the appropriate attributes of the IS project and then to define the relationships among the attributes and estimated cost. Figure 1 shows a general model for the process of estimating costs for an IS project. It indicates that the attributes of the project are used to estimate the effort required to

Figure 1. A Process Model for Estimating Costs for an IS Project.

(Banker, Datar, Kemerer, & Zweig, 1993; Wolff, 1992)

complete it, with effort as a function of the required resources and the duration of their use. Estimated cost is the total cost of all the required resources over the estimated duration. The relationships among the components of the model are synergistic in that they influence and impact one another (Scott, 1997). For example, the availability and quality of resources, both technical and human, can significantly change effort as well as estimated cost and can, in turn, change the project's attributes. Hence, the relationships in the model are bi-directional, and the process is iterative.

There are numerous methods for predicting the relationships among the components of the model (Albrecht & Gaffney, 1983; Bailey & Basili, 1981; Boehm, 1981; Freiman & Park, 1979; Giles & Barney, 1995; Herd, Postak, Russell, & Steware, 1977; Nelson, 1966; Putnam, 1978; Rubin, 1983; Walston & Felix, 1977; Wolverton, 1974); consequently, estimated costs can vary significantly. Although a significant body of research on cost estimating models exists and much has been learned about estimating project costs, the relationships among project attributes and costs are largely project-specific. As a result, cost estimating models and tools are presented in the research as a way to improve project planning and control not as a final authority for accurately determining costs.

Although there are some significant differences between new software development projects and maintenance projects, the model presented in Figure 1 is applicable to both types of projects. The process for estimating costs is the same for both even though the resulting effort, elapsed times, and costs may differ between the two types of projects because the project attributes and their relationships with costs can differ.

Estimating Costs for Year 2000 Compliance Projects

Year 2000 compliance projects have much in common with other software projects but are unique in many ways. They are often considered to be maintenance projects because they involve primarily enhancement of the capability of existing software, repairing or replacing all applications and other system components that are non-compliant in the correct processing of dates spanning the 20th and the 21st centuries. Yet these projects are similar to new software development in size and complexity. A unique attribute of year 2000 projects was an immutable deadline. At least for mission critical systems, they could not overrun the deadline.

Many attributes contributed to the total cost of a year 2000 compliance project: including the repair and/or replacement of affected applications, hardware verification and replacement, and often testing of many integrated applications. These projects therefore required coordination of testing and implementation of applications not only within the organization but also with interorganizational applications. The scope and complexity of testing and implementing these changes internally and externally was possibly one of the most significant attributes of these projects. As a result, estimates for the percent of project time that should be allocated for testing and integration ranged from 30 to 50 percent (Fowler, 1996; Jones, 1998a, 1998b; Phelps, 1995; Vangelova, 1997). In fact, Capers Jones (1998a) recommended that, as a general rule of thumb, testing and regression testing would take about 60% as much effort as the repairs themselves and more than half the calendar time of the project.

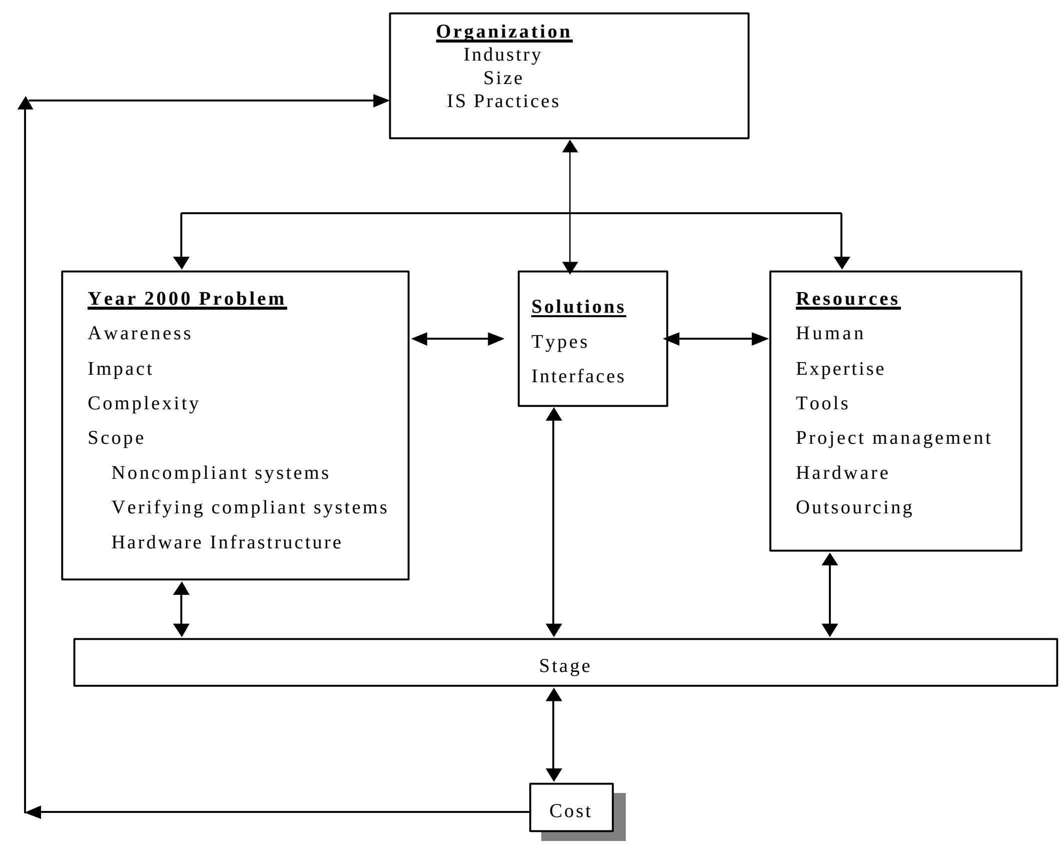
The Year 2000 Enterprise Cost Model in Figure 2 (Kappelman, Fent, Keeling, & Prybutok, 1998) shows the relationship of project attributes, resources, and costs. It suggests that there are five main categories of project attributes that influenced estimated costs for year 2000 compliance projects: (1) the organization, including its general IS development practices, (2) the extent and complexity of its year 2000 problem, (3) the solution methods chosen, (4) the project resources, and (5) the stage of project completion. This model is a special case of the general process model for estimating cost, even though effort is not explicitly shown.

The Research Problem

The primary goal of this research was to provide insight and prescription for long-term improvements in the cost-estimating methods used in IS projects. The year 2000 date problem provided a fortuitous research opportunity to study cost estimating with many similar IS projects in progress in IS organizations throughout the world. This was a rare opportunity to have a large number of projects with the same basic requirement, year 2000 date compliance, occurring concurrently with the same deadline.

The main purpose of this research was to identify the attributes or characteristics which influence an IS project's estimated costs. Five categories of project cost influences or attributes were examined: (1) organization, (2) project, (3) solution, (4) resources, and project stage. The anticipated outcome was to identify the significant cost relationships among project cost influences and estimated costs. A secondary goal was to provide short-term insight into the influences that are particularly important in managing IT projects for cost control and efficiency. To that end, this research proposed to test the Year 2000 Enterprise Cost Model (Figure 2) using a survey of year 2000 project managers primarily from member organizations of the Society for Information Management (SIM) -- one of the leading organizations in the IS field with a diverse membership from approximately 1500 organizations, representing industry, government, and education. The relationships among the year 2000 project attributes and estimated costs were examined to determine what relationships were statistically significant and if the significant relations differed when moderated by project stage.

Firgure 2. **Year 2000 Enterprise Cost Model**



(Kappelman et al., 1998)

This research investigated five research questions, derived from the Year 2000 Enterprise Cost Model (Figure 2):

1. Do organizational characteristics -- size, industry, and IS practices -- influence estimated costs of IS projects?

2. Do the characteristics of the problem in an organization -- awareness, impact, complexity, size, and scope -- influence estimated costs?

3. Do the characteristics of the solution chosen by an organization influence estimated costs?

4. Do available resources in an organization -- human, expertise, tools, project management, hardware, and outsourcing -- influence estimated costs?

5. Are estimated costs related to the stage of completion for year 2000 compliance projects?

Significance of the Research

At the current time, cost estimating tools have not proven to be reliable (Cowan, 1985; Kitchenham, 1992; Kusters et al., 1990; Littlewood, 1987) and, in many instances, do not provide adequate predictions of project costs. It is recommended that project cost estimates be used not as a solution to the question of how much a project will cost but as a second opinion and a vehicle for communication (Van Genuchten & Koolen, 1992). Examining the relationships among project attributes and estimated costs for year 2000 projects possibly provides a deeper understanding of the relationships that are a fundamental component of cost-estimating models. Furthermore, what is learned about cost estimating for year 2000 projects can provide insight for estimating costs for both new development and maintenance projects, since year 2000 projects have many attributes in common with both these types of projects.

Although opinions differed on the actual costs of year 2000 compliance projects, the estimated cost figures were very large and highly uncertain, regardless of the source (Caldwell, 1997; Cohen, 1997; deJager & Bergeon, 1997; Hall & Schick, 1996; Jones, 1997a; Kappelman et al., 1998; Vangelova, 1997). As the comparison of aggregate costs for the US and globally in Table 1-1 indicates, the magnitude of the problem was very large.

<u>Table 1-1.</u> Comparison of Aggregate Estimates for Year 2000 Compliance (in billions)

		Gartner Group	SPR	SIM
Global:	Total	300-600	530	322-486
USA:	Total	200	70	136.4
	Private sector	n/a	n/a	125.0*
	Federal government	30	n/a	8.1
	State governments	n/a	n/a	3.3

SPR = Software Productivity Research
n/a not available
* base amount does not include software purchases

(Kappelman et al, 1998)

Accurately estimating costs (and predicting resource requirements and schedules) for a year 2000 project became increasingly important for the organization as the deadline approached, particularly in allocating resources in order to manage these projects successfully. It was important that managers of these projects be able to leverage their available resources to both meet the deadline and to minimize the negative impact on the organization. Unlike most other software projects, year 2000 systems, at least in so far as mission critical systems were concerned, could not overrun their schedules because the deadline could not be extended. Organizations could only dedicate more resources to such projects; as a result, the available resources, particularly people, cost more as the deadline approached. The accuracy of the cost estimates of these projects may have had a significant part in determining the deleterious impact of year 2000 on organizations and increased the risk of not completing these projects on time. The estimated litigation costs for the U.S. alone was $100 billion (Bouwens, 1995; Jones, 1997a, 1997b, 1998b).

There is also an indication (Howard & Graham, 1997; Lederer & Prasad, 1995a, 1995b) that project managers were as important to the success of year 2000 projects as the IS professionals who completed the necessary repair and replacement of applications. James I. Cash, Jr. (1997) predicted that year 2000 projects would initiate the "age of execution" for software projects where success for project managers is defined as the ability to deliver high-quality projects on time and that these projects would change delivery expectations for all software projects. If this prediction proves to be true, what was learned from these projects may significantly impact future IS projects and change expectations for delivery of software projects.

Definition of Terms

The following list presents the definitions used for this research:

1. Software project*:* A project for development of new software or for maintenance or change to previously developed software.
2. Year 2000 problem: Century date processing problems that may result from the inability of computer-based systems to handle dates that span 2 or more centuries, particularly the 20th and 21st.
3. Year 2000 compliance: Characteristic of computer-based systems that can handle dates that span 2 or more centuries without any problems.

4. Year 2000 compliance project: A project to repair and/or replace, as well as test and verify systems to make them year 2000 compliant.
5. Software maintenance project: Any software project that requires modifications or enhancements of existing software applications or systems.
6. Software development project: Any software project that creates a new software system or application or that provides extensive enhancements to an existing application or system.
7. Estimated project cost: The total anticipated costs for any software project.

Limitations and Key Assumptions

A key assumption in the research is that Year 2000 compliance projects have many attributes in common with both new development and maintenance projects, but they also have many unique attributes, which will inherently limit the generalizability of the findings of this research.

There are also limitations in some of the factors upon which this research is based. For example, identification of the cost influence factors is pragmatically constrained in several ways. First, these factors must be general enough to represent a useful range of year 2000 projects and specific enough for the results to be useful to IS project managers. Secondly, the influences must be limited to those, which are the most closely related to estimated cost. As the number of influences increases, the cost in time and money for estimating cost also increases and will eventually reach the point where the value of the estimate is worth less than the cost of developing it.

Also, another limitation of this research is that it included quantitative methods only. A full understanding of year 2000 cost estimating for an organization would require an understanding of the individual organization, its year 2000 problem, and its solution and would require the use of qualitative methods for data collection and analysis. However, the primary limiting factor and reason for use only of quantitative methods was the time constraint.

Summary

The accuracy of estimating costs for information system projects is crucial for not only selecting and scheduling projects initially but for determining staffing levels and controlling implementation. Cost estimates have historically been unreliable, the credibility for the cost estimates given by IS managers is low, and project overruns are common. Year 2000 compliance projects presented an opportunity to study many similar projects and to examine the relationships among the five cost influence categories -- organization, problem, solution, resources, and project stage and estimated costs. The purpose of this research was to provide insight for IS managers concerning these relationships for estimating costs initially and for managing and delivering projects within their estimated costs.

CHAPTER 2

REVIEW OF LITERATURE

Introduction

This chapter presents a review of the literature on cost estimating models for software development projects and a discussion of how these models relate to year 2000 compliance projects. A review of theoretical cost estimating models will be presented first, followed by a discussion of empirical models, with the Year 2000 Enterprise Cost Model presented last.

Theoretical Models

There are two major types of cost estimating models, political and rational. Political models largely ignore project attributes and their impacts on costs and determine estimated cost based on external factors or the behavioral biases of the organization. Rational models use objective methods to develop the most accurate estimate possible, using available project information. In 1981, Boehm categorized theoretical software project cost-estimating models into six categories -- bottom-up, algorithmic, expert judgment, top-down, analogy, Parkinson, and price-to-win -- and these categories remain current today. Table 2-1 shows Boehm's (1981) summary of theoretical cost estimating models by type with the strengths and weaknesses of each.

Political Models

Political models identify and use the relationships and influences of stakeholders in determining estimated costs rather than the attributes of the project itself. The Parkinson and price-to-win models are the two categories that Boehm identified that would fall within the political type. The Parkinson principle, that work expands to fill the available volume, equates the cost estimate to the cost of available resources. The accuracy of this prediction is determined solely by how closely the resources available matched the required resources for completion of the project. In the price-to-win model, the cost estimate is equated to the price believed necessary to win the job or the schedule believed necessary to be first in the market with a new product. Political models are not widely accepted for accurately predicting project costs, however. This research will focus largely on rational models since political models do not use the relationships among project attributes for estimating project costs.

Although the accuracy of these methods is questionable (Boehm, 1981), there is evidence that political influences are often a factor in cost estimating (Grover et al., 1988), particularly in early estimates. Studies of year 2000 projects indicate that political influences play may a role in when year 2000 projects are begun as well as in estimating their costs. Kappelman et al. (1998) found that there is a high level of confidence in many organizations that their year 2000 projects will be completed on time and within budgets yet other findings show they have made little progress toward completion of these projects. This optimism may well be the political influence of denial of these projects rather than true confidence.

Rational Models

There are two common elements in rational models for estimating cost: (1) identifying the project attributes that influence costs and (2) predicting how these attributes will influence project costs. An estimate of the effort required for completing a project (usually defined by denoting the amount of human resources required over time, such as man-months) is often derived from the project attributes, and then the final cost estimate is the sum of the costs of all the resources required. The general process model for estimating costs for an IS project, shown earlier in Figure 1 in Chapter 1, represents the process from a rational cost estimating perspective.

The creation of an estimate using a rational model is not necessarily a single event but often a serial, iterative process requiring considerable effort to continuously refine a number (Lederer et al., 1990). When estimated costs are utilized in the management of a software development project as well as for the initial assessment of project value, it is important that cost estimates continue to be refined and reassessed throughout the project. Research concerning project attributes and their influences on costs (Boehm, 1981; Lederer & Prasad, 1995a, 1995b; Giles & Barney, 1995) indicates a positive relationship between the accuracy of cost estimates and the information, both historical and current, that is available. Logically, as a project progresses toward completion, both the accuracy and the availability of project attribute information should improve. Differences in rational models often relate to the amount of information needed and the time required for collecting and analyzing it. Since it is often necessary to have an early estimate before comprehensive project attribute data are available, the selection of a particular model to use often relates to the information available and, consequently, to the stage of a software project.

The size and complexity of a project are particularly important attributes (Boehm, 1981, Laranjeira, 1990; Lokan, 1996; Verner & Tate, 1987) and often the starting point for predicting effort. Gaffney, Cruickshank, Werling & Felber (1995) studied cost estimating using size as in independent variable and, for any given application domain, found that cost is more a function of size than of any other factor. They recommend as do many other researchers (Boehm, 1981; Jones, 1996a; Lederer & Prasad, 1992a) that project managers should re-estimate product size throughout the software development process.

The IS practices of the organization can also determine which models can be used for estimating costs for projects. IS practices, to a large degree, determine what historical information is available for analyzing project attributes and for assessing the productivity and effectiveness of resource utilization. Gaffney et al. (1995) group cost estimating models into three levels; holistic, activity-based, and system; and found a relationship between cost estimating level and the IS practices of the organization, using the Software Engineering Institute's (SEI) Configuration Maturity Model (CMM) (Humphrey, 1989; Jones, 1994a). They define holistic models as overview models that give rough estimates of software development labor costs and schedules based on limited attributes and information from the past experiences of the organization. Holistic models are most often used by organizations in the lower levels of maturity. Activity-based models use a bottom-up approach to analyze each activity of the project based on more extensive knowledge concerning prior projects. These models require that information from prior projects be accurately tracked and are most often used by organizations in the middle levels on the SEI scale. System cost estimating models are based on top-level system knowledge of the hardware and software to be developed and include software cost risk management. System-level cost estimating models include analysis of projects from an organizational perspective as well as based on prior projects. System models were found to be used most often by organizations that reported IS practices at the highest SEI levels.

Each software project is unique and the accuracy of any cost-estimating model is determined by how closely it fits the project being estimated. Calibration of a model is the process of tuning the influence factors in a model as closely as possible to the specific project and organization for which the estimate is being done. The level of calibration that can be done to refine a cost estimate varies by model and also with the current and historical information that is available.

Five of the categories Boehm identified for theoretical models would be classified as rational; the bottom-up, algorithmic, expert judgment, top-down, and analogy. The differences among the five categories are primarily in which project attributes are included in the analysis and the method used for analyzing the selected attributes to predict costs. Hence, the general process model for estimating costs for an IS project, Figure 1 in Chapter 1, is applicable for all five rational models.

Bottom-up estimating is perhaps the most widely used method and involves successively decomposing the software project into subunits or tasks until the individual responsible for the implementation of it can estimate the costs for each component of the project. A strength of this model is that the familiarity of the project members with the components they estimate lead to a high degree of accuracy. The estimates for the individual tasks can then be summed to produce a total cost estimate. A limitation of this model is that it cannot accurately predict cost until all tasks have been identified; thus, this method cannot be used in the early stages of a project, although it is

Table 2-1. Summary of Theoretical Cost-Estimating Models.

Method	**Type**	**Strengths**	**Weaknesses**
Bottom-up	Rational	More detailed basis More stable Fosters individual commitment	May overlook system-level cost Requires more effort
Algorithmic	Rational	Objective, repeatable, analyzable formula Efficient, good for sensitivity analysis Objectively calibrated to experience	Subjective inputs Assessment of exceptional circumstances Calibrated to past, not future
Expert judgment	Rational	Assessment of representative interactions, exceptional circumstances	No better than participants Biases, incomplete recall
Top-down	Rational	System level focus Efficient	Less detailed basis Less stable
Analogy	Rational	Based on representative experience	Representativeness of experience
Parkinson	Political	Correlates with some experience	Reinforces poor practice
Price-to-win	Political	Often gets contract	Generally produces large overruns

(Adapted from Boehm, 1981 page 342)

often important to have an early cost estimate. Other limitations for use of the bottom-up method are that the process requires considerable effort before an estimate can be derived, and it may overlook system level and integration costs. Identifying the components of year 2000 projects and the need for a bottom-up approach to cost estimating has largely been recognized (Kappelman, 1996), but the time and complexity of inventorying applications has proven to be difficult, primarily because of the size and scope of these projects. System level costs, particularly for testing and integration of multiple sub-projects, as well as interorganizational interfaces are proving to be important considerations for year 2000 projects as well, as much as 30% or more of total project costs (Jones, 1998b). Many of the integration and testing costs could potentially be missed or significantly underestimated using a bottom-up approach, however.

An alternate method of estimating costs more appropriate in the early stages of a project is the use of algorithmic models. Algorithmic models estimate costs using one or more formulas and produce a software cost estimate as a function of a limited number of attributes that are considered to be major cost drivers. In general, algorithmic models use a combination of software size metrics and productivity factors to estimate costs. The productivity factors add weights for the influences of various project attributes into the algorithm and are usually derived from historical data of the organization or the industry overall. The most common size metrics currently used as input to these models are lines of code (Boehm, 1981) and functions points (Jones, 1981, 1995). New technologies such as computer-aided software engineering (CASE) (Cockcroft, 1996) and object-oriented applications (Jones, 1994b) required new metrics for size or adaptation of existing ones. Many metric variations for measuring size and complexity have evolved from the original function point metric (Crockcroft, 1996; Cote, Bourque, Oligny & Rivard, 1988; Jeffery, Low & Barnes, 1993; Jones, 1994b, Matson, Barrett & Mellichamp, 1994). Cost as a percent of IS budget (Kappelman et al., 1998) has been proposed as a metric for estimating the cost of year 2000 projects as well as lines of code and function points.

The strength of algorithmic models is that they are objective, repeatable, and efficient and can be calibrated based on prior projects. These models can provide an early estimate of costs with less information and effort than using the bottom-up approach. Weaknesses of algorithmic models include their subjective inputs, the lack of allowance for exceptional circumstances, and the fact that calibration on past experiences may not accurately estimate projects, particularly projects using different technologies.

Estimating cost based on expert judgment involves consulting one or more experts. These experts use their experience from past projects and their understanding of the proposed project to estimate its cost. An expert-consensus mechanism such as the Delphi technique may be used to derive an estimate from a number of experts. Expert judgment estimates are very individualized and can range from a quick response that is timely and efficient but hard to calibrate and rationalize, to a well-documented group-consensus estimate that is time consuming but soundly based and analyzable. The strengths and weaknesses of using expert judgment for estimating costs are highly complementary to those of algorithmic methods, since the expert can factor in exceptional circumstance for the project, personnel and other unique project considerations. The weakness of this method is that the estimate is no better than the expertise and objectivity of the estimators.

In the top-down model, an overall cost estimate for the project is derived from global properties of the software product. This total cost is then split up among the various components. The major advantage of top-down estimating is that it has a system level focus and should include costs for integration, user manuals, and other system level functions that can be easily missed using bottom-up approaches. A disadvantage, however, is that it often does not identify components of the software or technical problems that are likely to escalate costs. Other disadvantages are that there is no detail available for cost justification, it is not replicable, and it is less stable than the bottom-up approaches.

The analogy model bases a cost estimate on a similar project. The actual costs of one or more completed projects are used to derive the estimate of a similar new project. Estimates by analogy can be done either at the system level or at the subunit level. There is a renewed interest in analogy models, particularly case-based reasoning, for estimating costs (Mukohpadhyay, Vincinanza & Prietula, 1992; Samson, Ellison & Dugard, 1997; Shepperd & Schofield, 1997; Vicinanza, 1990), primarily because the algorithmic models have not provided estimates with a high level of accuracy. The analogy model can also be used from a top-down or from a bottom-up perspective. The main advantage of this method is that the estimate is based on actual experience and that experience can be studied to determine specific differences and their likely cost impact. A disadvantage of this model is that the accuracy of the estimate is largely determined by the representativeness of the past experience to the current project. Use of a pilot project in estimating year 2000 project costs is recommended as an important practice for accurately predicting the resources required by a particular project (Fowler, 1996; Keanne, 1996).

The main conclusions Boehm derived from his research concerning rational models are:

1. None of the alternatives is better than the others from all aspects.
2. The Parkinson and price-to-win methods (the political models) are unacceptable and do not produce satisfactory cost estimates.
3. The strengths and weaknesses of the other techniques are complementary (particularly the algorithmic models versus expert judgment, and top-down versus bottom-up).

In practice, project managers should use a combination of these rational methods and techniques, compare their results, and continue to refine their estimates as software projects progress toward completion.

Empirical Models

Conte, Dunsmore, and Shen (1986) analyzed existing empirical cost estimating models and identified over 20 software models in the literature including COCOMO (Boehm, 1981), Doty (Herd et al., 1977), SLIM (Putnam, 1978), PRICE_S (Frieman, 1979), ESTIMACS (Rubin, 1983), and Function Points (Albrecht & Gaffney, 1983). Giles and Barney (1995) found that there were more than 50 models in use in 1995. Conte et al. (1986) group empirical models into three categories based on the method of analysis; historical-experiential models, statistically based models, and composite models. Historical-experiential models project cost based on prior experiences and past projects and include four of the theoretical models -- expert judgment, analogy, top-down, and bottom-up. At the time of their research, they felt that most of the cost-estimation methods fell within the historical-experiential category and past experiences remain a key element in estimating costs.

The second category of existing models is statistically based models, which would be equivalent to the algorithmic theoretical model category. These are largely based on regression analysis to determine the relationship between project attributes and effort. A number of models, both linear and nonlinear have been proposed (Farr & Zagorski, 1965). Project size is a fundamental project attribute in these models, and lines of code and function points are common size metrics in these models.

Composite models use a combination of historical-experiential and statistically based methods for estimating costs. Most cost estimation tools today are composite models. They are statistically based but allow calibration, at least to some degree, for the specific project and organization, using historical-experiential information. The RCA Price S model (Bailey & Basili, 1981) uses project size, type, and complexity as the primary attributes to produce a top-down estimate of the cost of system functions by project phase. COCOMO (Boehm, 1981; Gaffney et al., 1995) is probably the most widely used composite model today and has been an important factor in the maturing of cost estimating models since its algorithms have been openly published. The algorithms and models underlying most other cost-estimating tools are proprietary and not available for analysis.

Calculations of effort and time for development are the fundamental components of the COCOMO model. Effort is a function of lines of code and time for development is a function of effort. There are now many variations of COCOMO, and many of the empirical models and cost estimating tools are based upon the models defined by Boehm. COCOMO offers three different models for estimating costs -- Basic, Intermediate, and

Detailed. Differences among the three levels highlight the importance of what project attribute information is available during the cost estimating process.

In Basic COCOMO, estimated cost is a function of only one project attribute, size. The Intermediate and Detailed modes incorporate adjustments for additional project attributes and the project overall and allow adjustments for each project component. Within each of these levels, however, the COCOMO model has been adapted for three different software project environments or modes: organic, semi-detached, and embedded. In the organic mode, relatively small software teams with extensive experience on similar projects develop software in a highly familiar hardware and software environment. The other extreme is embedded mode where projects operate within (i.e., is embedded in) an ambitious, tightly constrained hardware, software, and/or external environment. The embedded software team is charting its way through unknown territory to a greater extent and has fewer decision options for software changes and fixes. The semi-detached mode falls between the organic and embedded environments. Organic mode teams are the most productive; and embedded, the least. Within each level the weighting factors are calibrated to reflect the productivity differences of these environments.

Basic COCOMO is good for quick, early, rough order of magnitude estimates but its accuracy is limited because of the lack of factors to account for differences in many project attributes. In the Basic COCOMO model, effort in man months and time for development are calculated based solely on project size in thousands of lines of code (KDSI). As Table 2-2 shows, the difference between modes is a difference in the constants and exponents used for the calculations of man-months and time for development. The only calibration that can be incorporated is the adjustment of these at the overall project level by adjusting the lines-of-code metric.

Intermediate COCOMO adds effort multipliers (i.e., weights) for fifteen cost drivers, grouped into four categories; (1) product attributes, particularly size and complexity; (2) hardware attributes, (3) personnel attributes, and (4) IS environment attributes. See Table 2-3 for a summary of the cost drivers identified in the COCOMO model. Intermediate COCOMO includes a Component Level Estimating Form (CLEF) that permits use of the model at the component level. Cost multipliers for the 15 project attributes can be set for the individual project component rather than for the overall project. The addition of CLEF allows the project manager to optimize the required resources throughout the stages of the project to better manage the project as it progresses. COCOMO can thus be used at the macro level for an early, rough estimate and at the micro level in the later, more-detailed stages as the project progresses toward completion.

Table 2-2. Basic COCOMO Effort and Schedule Equations.

Mode	Effort	Schedule
Organic	$MM=2.4(KDSI)^{1.05}$	$TDEV=2.5(MM)^{0.38}$
Semidetached	$MM=3.0(KDSI)^{1.12}$	$TDEV=2.5(MM)^{0.35}$
Embedded	$MM=3.6(KDSI)^{1.20}$	$TDEV=2.5(MM)^{0.32}$

MM = man months, KDSI = thousands of lines of code, TDEV = time for development

(Boehm, 1981, page 75)

Detailed COCOMO adds phase-sensitive effort multipliers for each cost driver and a three-level product hierarchy. In Intermediate COCOMO, the phase distribution of effort is determined solely by the size of the product. In practice, factors such as reliability and experience affect some phases more than others. Detailed COCOMO includes options for assigning cost driver weights at three different levels -- module, subsystem and system -- whereas intermediate COCOMO requires different cost driver ratings for each component. This hierarchy eliminates unnecessary repetition and tedium. The addition of the Intermediate and Detailed COCOMO models increases the usefulness of the model for

Table 2-3. COCOMO Cost Drivers	
Project Attributes	
	RELY - Required software reliability
	DATA - Data base size
	CPLX - Product Complexity
Computer Attributes	
	Time - Execution time constraint
	STOR - Main storage constraint
	VIRT - Virtual machine volatility
	TURN - computer turnaround time
Personnel Attributes	
	ACAP - Analyst capability
	AEXP - Application experience
	PCAP - Programmer capability
	VEXP - Virtual machine experience
	LEXP - Programming language experience
Project Attributes	
	MODP - Modern programming practices
	TOOL - Use of software tools
	SCED - Required development Schedule
	(Boehm, 1981, page 345-346)

cost estimators to calibrate the model to the specific project. Historical experiences can be incorporated into the model as well as adjustments for unique attributes of a project.

The COCOMO model illustrates that improving cost estimating results depends on learning as much as possible about the relationships between the project attributes and costs and utilizing this information in the calibration process. Research on cost estimating models fall primarily within four categories: (1) testing and comparing current models (Heemstra, 1992; Kitchenham & Taylor, 1985; Mukhopadhyay & Kekre, 1992; Navlakha, 1990; Shepperd & Schofield, 1997; Subramanian, 1993), (2) refinement of models (Banker, Chang, & Kemerer, 1994; Briand, Basili, & Thomas, 1992; Ferens, 1988; Henderson-Sellers, 1997; Hu, 1997: Jeffery et al., 1993; Kesh, 1995; Marouane & Mili, 1991; Park, 1988; Pillai & Nair, 1997; Subramanian & Breslawski, 1993; Wang, 1993), (3) understanding the relationships among project attributes and estimated costs (Plfeeger, 1994, Schnopp, 1989), and (4) refinement of calibration methods (Cuelenaere, van Genuchten, & Heemstra, 1987; Gulezian, 1991; Murali & Sankar, 1997; Young, 1990).

Researchers during the early years sought primarily to improve the algorithmic processes with the goal of finding the “best” algorithm. Current research recognizes the imperfection of estimates from all models and the need to use multiple models. The importance of human factors in cost estimating has been recognized as well as the value added by triangulation in use of different models and modelers. There is a high degree of consensus among cost estimating researchers that models and methods are tools for assessment of value and subsequently management of projects, not as infallible predictors of project costs. The common denominator of all cost estimating research is understanding the relationships among project attributes and project costs, however. What is learned about these relationships from this research can be incorporated into all four areas of cost estimating research.

The Year 2000 Enterprise Cost Model

Figure 2 in Chapter 1 shows the Kappelman et al. (1998) Year 2000 Enterprise Cost Model with five main categories of cost influences: (1) the organization, (2) the extent and complexity of its year 2000 problem, (3) how it will be solved, (4) available resources, and (5) the stage of project completion. The cost influences shown in this model relate closely to the cost driver attributes of the COCOMO model. The year 2000 problem and solution categories of the year 2000 model correspond closely to the product attributes category of the COCOMO model. The organization category of the year 2000 cost model corresponds to the project attributes category in COCOMO, and the resources category of the year 2000 cost model includes the attributes from both the computer and personnel categories of the COCOMO model. The similarity of the year 2000 model and the COCOMO model is further supported by the fact that the initial testing of the year 2000 model found support for all five categories shown in the model (Kappelman et al., 1998).

The COCOMO model does not include a specific variable for project stage, but the different models of COCOMO were derived to accommodate varying information requirements and, consequently, reflect project stage. The BASIC mode is intended for an early, rough estimate and is intended to be a macro estimate whereas the Intermediate and Detailed modes are intended for use at the micro level after a successively more thorough analysis of the project has been completed. The stages of year 2000 projects do differ somewhat from the stages of other software development projects, primarily by the addition of an awareness stage prior to initiation of a year 2000 project. Project stages for year 2000 projects have been defined by Kappelman and Cappel (1996) in their year 2000 project process model that includes (1) awareness, (2) acceptance, (3) impact analysis, (4) planning and scheduling, (5) conversion, and (6) testing, and (7) implementation. Since the scope and makeup of year 2000 compliance projects is somewhat unique, their stages may differ in context as well as in length when compared to other software projects.

Kappelman et al. (1998) found that the estimated cost of year 2000 compliance reported by project managers, as a percent of annual IS budgets was approximately 25% for projects in the early-planning stage and approximately 36% for projects in the later-planning stage. This difference implies that estimated costs for year 2000 projects might increase as more is learned, as estimated costs for other software projects often do.

One of the important differences of year 2000 projects in comparison with other software development projects is their scope. Year 2000 projects often require the coordination, testing, and integration of many subprojects (both internal and external to the organization) beyond the scope of a normal software development project. Thus the system level influences on costs may prove to be higher for year 2000 projects than those of other software projects. Although the project attributes identified for software development projects and year 2000 projects are similar, the relationships between these attributes may differ significantly. Likewise, although the components of cost estimation models for new software development and maintenance are similar, there are often many differences in the relationships and the influences of project attributes on cost.

Summary

The Year 2000 Enterprise Model has much in common with the COCOMO model, the most widely used empirical model. The COCOMO model is based on rational costs estimating models and recognizes the importance of the human factor in cost estimating as well as the value that triangulation in use of different models adds. There is a high degree of consensus among cost estimating researchers that models and methods are tools for assessment of value and subsequently management of projects, not as infallible predictors of project costs. The common denominator of all cost estimating research is understanding the relationships among project attributes and project costs, however. The purpose of this research was to more fully understand the relationships among project attributes and estimated costs for year 2000 projects. The similarities and the differences of these projects with other software development and maintenance projects will be particularly important in assessing how this research can be used in the calibration process for applying organization and project-specific knowledge to cost estimating.

CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

Introduction

The overall research design was to explore in a field study the relationships identified in the Year 2000 Enterprise Cost Model (Figure 2 in Chapter 1), specifically in a survey of year 2000 project managers in industry, government, and education. This research was part of a joint project between the University of North Texas (UNT) and the Year 2000 Working Group of the Society for Information Management (SIM). The project began in 1996 with a survey of SIM member organizations to determine the status and progress of year 2000 compliance projects with plans for an annual survey through the year 2000. A summary of the findings from the 1996 and 1997 surveys were published to promote awareness and to serve as a benchmark for other organizations, and particularly for year 2000 project managers to use in managing their projects. Year 2000 compliance projects and the joint survey project presented a fortuitous opportunity to study many similar projects occurring at the same time with the same deadline. This research focusing on cost estimating was an ancillary study of the SIM-UNT project.

The data from the 1996 survey was used to develop the Year 2000 Enterprise Cost Model (Kappelman et al., 1998) and indicated that the mean estimated cost of year 2000 compliance was approximately 30% of annual IS operating budgets. An analysis of the 1996 projects indicated that projects in the early-planning stages had a mean estimated percent cost of approximately 25 percent and that projects in the later-planning stages had a mean of approximately 37%. Hence the interest in studying cost by project stage in this research. The 1997 survey allowed further study of these projects and further exploration of the relationships identified in the Year 2000 Enterprise Cost Model.

When referencing the model in this document, the term “dimension” was used to reference a major component of the model such as organization, problem, solution, resources, project stage, or cost. The term “sub-dimension” indicates the types or categories of cost influences within a dimension. For example, within the organization dimension, there are three sub-dimensions -- size, industry, and IS practices.

Hypotheses Derived from the Year 2000 Enterprise Cost Model

A null hypothesis (that no relationship exists) was developed to represent the relationship between each of the four cost influence dimensions in the model and estimated cost. A second hypothesis was developed for testing each of these relationships by project stage.

The null hypotheses, that no relationships exists, developed for testing the relationships among organization cost influences and estimated percent cost for year 2000 projects are:

> **H1: There is no relationship between organizational characteristics and estimated cost of year 2000 compliance projects as a percent of annual IS budget.**

> **H1A: There is no relationship between organizational characteristics and estimated cost of year 2000 compliance projects as a percent of annual IS budget when moderated by project stage.**

The model includes three sub-dimensions of organization cost influences -- industry, size, and IS practices -- that will be included in testing these hypotheses.

The null hypotheses developed for testing the relationships among the problem characteristic cost influences and estimated percent cost are:

> **H2: There is no relationship between year 2000 problem characteristics and estimated cost of year 2000 compliance projects as a percent of annual IS budget.**

> **H2A: There is no relationship between year 2000 problem characteristics and estimated cost of year 2000 compliance projects as a percent of IS budget when moderated by project stage.**

The model shows four sub-dimensions of problem characteristic cost influences -- awareness, impact, complexity, and scope.

The null hypotheses developed for testing the relationships indicated in the model for the year 2000 solution cost influences and estimated costs are:

> **H3: There is no relationship between year 2000 solution characteristics and estimated cost of year 2000 compliance projects as a percent of annual IS budget.**

> **H3A: There is no relationship between year 2000 solution characteristics and estimated cost of year 2000 compliance projects when moderated by project stage.**

The model indicates that there are two sub-dimensions of solution cost influences -- type and interfaces.

The null hypotheses developed to explore the relationships among the fourth category of cost influences, resources, and estimated percent cost for year 2000 projects are:

> **H4: There is no relationship between resources and estimated cost of year 2000 compliance projects as a percent of annual IS budget.**

> **H4A: There is no relationship between resources and estimated cost of year 2000 projects as a percent of annual IS budget when moderated by project stage**.

Human resources, expertise, tools, project management, hardware, and outsourcing are the sub-dimensions included in testing the relationship between resources and estimated costs.

The null hypothesis developed to explore the relationship between project stage and estimated percent cost for year 2000 projects is:

H5: There is no relationship between estimated cost of year 2000 compliance projects and stage of project completion.

If the null hypotheses are true, no relationships should be found for independent response variables identified to represent a dimension or sub-dimension of the model and estimated percent cost. If relationships are found, the null hypothesis will be rejected, and there is possible support that the relationship as indicated in the model exists. In testing the hypothesis by project stage, if the null hypothesis is true, there should be no differences between the results of the two groups selected on the basis of stage of completion.

Data Collection

Questionnaire Development

The SIM Year 2000 Working Group and the UNT research staff under the direction of Dr. Leon A. Kappelman initially developed the original survey instrument (i.e., questionnaire). The 1996 questionnaire was first distributed to a pilot group, selected by the working group members. The feedback and suggestions from the pilot group were incorporated into the official version of the 1996 questionnaire that was distributed in the summer of 1996.

The 1996 questionnaire included two formats; one for the year 2000 project manager and one for the top IS manager or chief information office (CIO) of the organization. The first three sections of the survey instrument were identical and included questions concerning, (1) the person filling out the questionnaire, (2) the organization, and (3) the organization's IS management, development, and maintenance practices. The project managers' questionnaire included a special section concerning the year 2000 project in their organization with detailed questions concerning the practices associated with solving in their year 2000 computer date problem

The 1996 questionnaire and the corresponding findings from it (Kappelman, 1996) were reviewed by the SIM Working Group, a selected group of outside IS professionals, and the UNT research group for completeness, accuracy, and clarity. Feedback from these reviews was incorporated into the 1997 questionnaire. Several questions were added and a few ambiguous questions were removed simply because their responses were not meaningful. In order to facilitate comparison between years, however, the number of changes was limited. See Appendix A for a copy of the 1997 questionnaire.

Instrument Validity

Instrument or measurement validity is the degree to which the concept or phenomena purported to be measured is what is actually measured. A threat to the validity of the questionnaire instrument is that it was recently developed and was not validated and refined over a long period of time. Nevertheless, the development process was fairly rigorous, with the use of experts in the field to develop and review the original questionnaire and with the use of a pilot group to test it. Terminology was chosen carefully and used consistently throughout. The survey instrument included carefully written instructions with examples for completing the questionnaire and definitions of terms. The expert review of the instrument and subsequent revisions in the 1997 version would appear to increase its validity further. The comparison of findings from 1996 and 1997 indicate that there was consistency in the use of the instrument between years as well.

A factor analysis process that is described later in this chapter was used to verify the validity of the questionnaire. The purpose of this analysis was to verify that the items selected to measure each construct or sub-construct of the model did align with each other on a common factor and that each factor representing a dimension or sub-dimension of the model was adequately measured.

External validity refers to whether a research finding generalizes to groups beyond the sample in which it was found. The fact that the respondents are representative of organizations in industry, government and education gives this study external validity. SIM, the source of most of the sampled population, is a widely known leading organization for IS professionals and has a reputation of respect in the field. The questionnaire packet included multiple letters of sponsorship from SIM and UNT and the packets were mailed to the highest-ranking SIM member of each organization in order to solicit support for completing the questionnaire. The SIM Year 2000 Working Group likewise has been active during the past three years and has gained a position of respect in the IS community. The position of these organizations in the IS community adds validity that the sample population is representative of the larger population of all organizations, and the fact that year 2000 projects have attributes in common with both new software development and maintenance may make feasible the generalization of these results to both types of projects.

Sampling Methodology

As in 1996, the target for the 1997 questionnaire was a sample of year 2000 project managers representing all major industry segments. Using the SIM membership rolls, the highest-ranking information officer (as indicated by title) was selected for each organization. Consultant organizations and academic institutions were eliminated from the sample unless the member, as indicated by title, was the person responsible for the IS operations of the organization. The sampled population included 1244 members using these criteria.

A small group of approximately 35 non-SIM organizations was selected as a control group. Mailing information for the non-SIM group was obtained using the *Directory of Top Computer Executives* published by Applied Computer Research. The responses from this population were to be compared with the responses of the SIM members to determine whether the larger SIM survey population was representative of year 2000 projects overall. The number of responses returned from this group was not large enough to make the comparison, however.

Mailing Preparation and Questionnaire Distribution

The packet mailed to the each of the 1244 selected SIM members contained letters of sponsorship from both SIM and UNT soliciting support for this project and asking that the enclosed survey packet be passed along to the organization’s year 2000 project manager. The packet for the year 2000 project manager contained similar sponsorship letters requesting participation in the study, as well as the survey instrument. The pre-paid return envelope included with the questionnaire was coded so that follow-up contact was possible if needed.

The questionnaires were mailed to the selected population of SIM and other organizations in mid July of 1997 with a requested return data of August 24, 1997. Two follow-up postcards were mailed asking the SIM member or top IS executive to encourage their year 2000 project manager to return the questionnaire. The deadline was extended to September 15, 1997. One hundred eighty-seven questionnaires were returned, giving a response rate of approximately 15%. The return rate, although low, was acceptable given the length of the questionnaire (19 pages) and the demands on the year 2000 project managers time during these date-critical projects. It was comparable to the rate for the 1996 questionnaire [Kappelman, 1996].

A threat to the response rate of a survey is the length of the questionnaire instrument, which in this case was nineteen pages including the instructions. Research indicates that to maximize response, questionnaires should be short, preferably not more than three or four pages. The decision was made to sacrifice response to some degree in order to get comprehensive information on the year 2000 compliance projects. To offset the anticipated lower response rate, the respondents were offered an incentive of receiving a copy of the article, “How Much Will Year 2000 Compliance Cost?”

[Kappelman, Fent & Prybutok, 1997], in return for completing the survey if they returned a business card with the survey.

Processing of Questionnaires on Return

As the questionnaires were received, they were processed as follows:

1. Each questionnaire was coded with the unique number for their organization from the return envelope.
2. The organization’s record in the mailing list database was updated with the return information.
3. The data from any enclosed business cards was entered into a database
4. The questionnaires were accumulated and sent to a professional data entry service in batches of approximately 50.

The data entry process included re-entry of 100 of the questionnaires for verification with an error rate of less than two-tenths of one percent. The data were manually validated as described below also. When all questionnaires were received, the article was mailed as promised to the respondents who requested it by returning a business card or their mailing information.

Data Analysis

The data analysis included descriptive statistics and frequencies to validate the data, factor analysis to validate the items selected to measure the dimensions and sub-dimensions of the model, and then correlations and t-tests to examine the relationships among the individual independent variables to test the five hypotheses. All the statistical analyses used the Statistical Package for the Social Sciences (SPSS) software.

Data Cleanup and Validation

The first step of the analysis was to generate descriptive statistics and to check for invalid and unreasonably outlying values. Frequencies provided an overview of the data, and suspicious values or anomalies were either removed from the data set or corrected by verification of the data entered from the responses on the questionnaire. Comparisons were made between like items to validate results to identify suspect data and to validate internal consistency. Several errors were found, and the decision was made to manually verify the data to ensure accurate entry. Lists were generated from SPSS, and student workers rechecked each questionnaire response against the lists. A bounty was paid for errors found, and the errors found were corrected.

Several outlying values remained, however, after the manual verification. Although these were accurate as reported by the respondent, the values were not logically possible and were removed from the data set, setting the field to missing values. The decision was made not to contact respondents to correct the data because the follow-up process would be lengthy. Unless the Y2K project manager returned his business card to receive the article, contact would have to be made back through the SIM member.

There were several areas of the questionnaire in which the respondent was asked to give percentages totaling 100%. In verifying responses, however, the totals often did not total 100. The decision was made to create new fields that were mathematically adjusted if the original totals fell between 80 and 110 percent, and if the totals were outside this range the responses were set to missing values. Zero responses, indicating that the question was not applicable or that the respondent did not know the answer, were set to missing values so that the mean statistics would accurately reflect the level of agreement or disagreement with the questions.

Instrument Validation

The independent variables for this study were the responses to the questionnaire items selected to measure each of the five dimensions of the Year 2000 Enterprise Cost Model -- organization, problem, solution, resources, and stage. The dependent variable selected to measure cost was computed as the total estimated costs of the compliance project for the organization divided by the annual IS budget of the organization. Kappelman et al. [1997] used this calculation in the development of the Year 2000 Enterprise Cost Model initially. This calculation standardizes estimated cost for size of the IS organization and will be referenced as “estimated percent cost” throughout this research.

As the Year 2000 Enterprise Model indicates, there are five major dimensions of the independent variables, but each of these dimensions may have sub-dimensions of cost influences within it. Each dimension of the model represents a construct, but each sub-dimension represents a construct at a lower level. For consistency, the terms “construct” and “dimension” are interchangeable in this document, and the term “sub-dimension” will be used to reference a lower-level construct or “sub-construct”.

The first step in the analysis was to identify the questionnaire items that measured each dimension or sub-dimension of the model and to use factor analysis to assess if the items selected were appropriate measures for their respective dimensions and sub-dimensions of the model. Tables 3-1 through 3-5 show the questionnaire items selected initially to measure each sub-dimension or dimension of the model and its factor loading on the uncorrelated factors when the items were forced into a single factor. Items with a factor loading of less than .30 were not confirmed as a valid measure for the construct or sub-construct. Nunnally (1978) proposed a minimum factor loading of .30 as the criteria for including an item as part of a factor, and his "item-dropping" technique has been widely used and accepted (e.g., Blau, 1985, Zaichowsky, 1985, Barki & Hardwick, 1994, Segars, 1994). Thus any item with a factor loading of less than .30 was not considered to be a valid measure of a dimension or sub-dimension and was excluded from further analysis.

Table 3-1. Questionnaire Items Selected To Measure The Organization Dimension (with factor loading values).

Size Sub-Dimension (explains 40.1% of the variance)	Loading
Gross revenues or income of the organization (division or parent).	.59
The number of people working in the organization (division or parent).	.72
What was the total operating budget of this IS organization during the last fiscal year?	.84
How many people work for this IS organization?	.87
How many total lines of code (in thousands) are in your organization?	.50
How many software applications are in your organization?	.38
How many separate data files are in your organization?	.32
IS Practices Sub-Dimension (explains 33.8% of the variance)	
This IS organization:	
Has a comprehensive and tested IS disaster recovery plan.	.38
Does extensive benchmarking to other IS organizations.	.54
Has a clearly defined and utilized software process methodology for:	
1. IS development.	.71
2. Application maintenance (i.e. minor changes).	.68
3. System conversion (i.e. large-scale changes).	.68
4. Change management (keeping track of versions, maintenance and conversions.	.55
Encourages project managers to recommend that software projects be terminated if they deserve to be.	.52
Encourages everyone on the project team to recommend that software projects be terminated if they deserve to be.	.55
Assigns those who develop programs the responsibility for maintaining them throughout their entire life cycle.	.06
Cost estimating for IS projects is based primarily on these metrics:	.
1. Number of lines of code	.41

2. Function points	.54
3. Other	.21
Cost estimating for IS projects is based primarily on these estimating methods:	
1. Top-down	.39
2. Bottom-up	.46
3. Historical data	.35
4. A combination of these	.33
Aspires to the software development practices of the Software Engineering Institute's Configuration Maturity Model.	.18
For software development and/or maintenance, this organization specifies and uses a comprehensive set of processes and/or procedures for:	
1. Establishing customer agreement on requirements.	.62
2. Estimating all resource needs.	.72
3. Tracking progress and resource use.	.67
4. Selecting, contracting, tracking and reviewing software contractors/outsourcers.	.68
5. Software quality assurance.	.78
6. Continuous process improvement.	.76
7. Identifying the training needs of IS professionals.	.58
8. Tailoring the process to project-specific needs.	.62
9. Coordination and communication among development groups.	.70
10. The examination of work products by peers.	.58
11. Measuring project progress.	.71
12. Establishing quality goals with customers.	.72
13. Analyzing problems and preventing re-occurrence.	.68
14. Evaluating new technologies and utilizing when appropriate.	.57
15. Continuous productivity improvements.	.71
16. Unit, system, acceptance and regression testing.	.65

Within the organization dimension, there are three sub-dimensions -- size, IS practices, and industry. Table 3-1 shows the factor loading for the questionnaire items initially selected to measure size and IS practices when forced into a single factor for each sub-dimension. Although the resulting factor for size only explains 40.1% of the variance, the seven items measuring size all have factor loading values above .30 so are confirmed as valid measures for size. The factor analysis using the items initially selected to measure IS practices confirms 30 of the 33 item selected with factor loadings above the .30 minimum. The resulting factor only explains 33.8% of the variance, however.

Table 3-2. Questionnaire Items Selected To Measure The Problem Dimension (with factor loading values).	
Awareness Sub-Dimension (explains 49.2% of the variance)	Loading
Regarding the year 2000 date problem in my organization:	
I closely follow this issue in the media.	.48
I regularly attend workshops or conference about this.	.47
This organization:	
Is well aware of the year 2000 date problems.	.60
Has had significant discussions of the year 2000 date problem with its	
Customers.	.73
Suppliers.	.83
Internal users.	.78
Trading partners.	.88
Software and hardware vendors.	.72
Impact sub-dimension (explains 48.5% of the variance)	
It will significantly impact our competitive advantage.	.79
It will significantly impact our ability to serve our customers/citizens.	.84
This is not a serious problem in this organization.	-.71
The year 2000 date problem will have a significantly negative effect on my organization.	.49
The year 2000 date problem will have no impact whatsoever on this organization.	-.59
Scope and complexity sub-dimension (explains 19.3% of the variance)	
Percentage of lines of code affected.	.31
Percentage of applications affected.	.29
Percentage of applications to replace.	.70.
Percentage of applications to modify.	-.11
Percentage of data files to modify.	.51
Percentage of screens and reports to modify.	.63
Percentage of source code missing.	.32
Percentage of hardware to upgrade or replace.	.71
Percentage of system software and utilities to be upgraded or replaced.	.63
Percentage of problem in purchased applications 10 or more years old.	-.13
Percentage of problem in custom applications 10 or more years old.	-.26
Percentage of problem in purchased applications less than 10 years old.	.04
Percentage of problem in custom applications less than 10 years old.	.29

There are four sub-dimensions within the problem dimension -- awareness, impact, complexity, and scope. Complexity and scope were grouped together in this research because they are closely related and because of the limited number of items concerning them in the questionnaire. Table 3-2 indicates that the eight items measuring awareness all have factor loading values above .4 and explain 49.2 percent of the variance. Likewise Table 3-2 indicates that the items measuring the impact sub-dimension all have loading values above .4 and explains 48.5 percent of the variance. Two of the items appropriately have negative factor loadings since the items are worded for agreement with a negative statement. The factor analysis for the items initially selected to measure complexity and scope confirms only seven of the 13 items as statistically valid measures for that sub-dimension and indicates that these only explain 19.3% of the variance.

Because the questionnaire items concerning the solution dimension for Y2K projects solicit only general progress information, the items selected to measure solution are not grouped into any sub-dimensions. The factor analysis confirmed 20 of the 30 items initially selected to measure solution as valid measures.

Table 3-3. Questionnaire Items Selected To Measure The Solution Dimension (with factor loading values).	
(Explains 28.3% of the variance).	Loading
This organization:	
Has studied the year 2000 problem, inventoried its applications, and conducted an impact analysis.	.80
Has completed an inventory of all hardware, software, and data assets.	.79
Has completed an impact study to determine the exact nature of our year 2000 problem on all hardware, software, and data assets.	.83
Takes year 200 date compliance into consideration in all new outsourcing and contract agreements.	.57

Takes year 2000 date compliance into consideration in all new licensing agreements.	.58
Has year 2000 date compliance covered in all existing outsourcing and contracting agreements.	.56
Has year 2000 date compliance covered in all existing licensing agreements.	.53
Has established standards for year 2000 date compliance.	.77
Has detailed plans, schedules and budgets for solving the year 2000 date problem.	.81
Has conducted pilots to validate its year 2000 budget estimates.	.73
Has already solved the year 2000 problem at the code and data level.	.42
Has already tested its year 2000 date compliance solutions(s).	.57
Has implemented and made operational its solution(s).	.57
Has already solved the problem and is year 2000 date compliant.	.32
Will implement or has implemented a:	
100% date field expansion.	.20
100% login-only and/or windowing solutions.	.20
Hybrid solutions involving both of these approaches.	.10
Has organization-wide definitions and standards for year 2000 date compliance.	.75
Has conducted a business risk assessment in order to uncover any year 200 exposure.	.70
Has prioritized projects according to the findings of business risk assessment.	.73
Has curtailed spending on other projects to provide resources.	.44
Systems integration is a very significant issue in resolving the year 2000 date problem.	.00
I expect no downtime of systems during installation and deployment of year 2000 modifications.	.08
I am very confident that we will be year 2000 date complaint with time to spare.	.41
I am very confident that we will be year 2000 date complaint within the amount of moneys budgeted.	.40
The percentage of time that you plan to spend:	
Determining scope of problem, inventorying applications, conducting impact assessment.	-.06
Planning, scheduling, budgeting and prioritizing.	.00
Converting and/or replacing code, modifying data, replacing hardware.	.13
Testing the solution.	.21
Making the solution operational.	.14

The model indicates six sub-dimensions within the resources dimension -- human resources, tools, expertise, project management, hardware, and management support. In the factor analysis for resources, however, the items concerning the adequacy of the resources available for Y2K projects fell out as a separate dimension rather than each item aligning with items concerning similar resources. Thus the analysis included seven sub-dimensions for resources. The six items concerning adequate resources load on a single factor with strong factor loading values and explain 66.6 percent of the variance (see Table 3-4). All the items selected to measure external human resources load into a single factor that explains 57.4 percent of the variance. The low loading value for the item concerning “offshore programmers” in comparison to the high values for the other items concerning external help may indicate that the term was not understood. It was not defined in the questionnaire.

The factor analyses for hardware, expertise, tools, and management support confirm the items selected to measure each sub-dimension as valid measures with factor loading values of .65 or higher. The analysis for hardware resources indicates that 64.6 percent of the variance is explained and that all four items have strong loading values (e.g., .7 or higher). Likewise the items measuring expertise explain 56.8 percent of the variance, and all have loading values of .59 or higher. The analysis of the items selected to measure tools explains almost 50 percent of the variance and shows moderately strong loading values (i.e., .58 or higher). The six items selected to measure management support explain 66.2 percent of the variance and have loading values of .8 or larger.

Table 3-4. Questionnaire Items Selected To Measure The Resources Dimension by Sub-Dimension (with factor loading values).	
Adequacy of Resources (explains 66.6 % of the variance)	Loading
As year 2000 project manager, I have complete adequate:	
Authority.	.85
Money.	.86
Human resources.	.86
Management support.	.88
Hardware capability.	.80
Time.	.67
Human Resources (explains 57.4% of the variance)	
This organization will rely on ______________for external help with year 2000 date problem solutions:	
Outsourcing and contractors	.89
Offshore programmers	.39
Consultants	.88
Hardware (explains 64.6% of the variance)	
Hardware capacity is very adequate for compliance testing.	.81
This organization has adequate test facilities:	
For mainframe applications and products.	.85
For midrange applications and products.	.84
For microcomputer applications and products.	.70
Expertise (explains 56.8% of the variance)	
The people assigned are extremely well experienced at software maintenance.	.79
The expertise of our year 2000 project team is totally adequate in the following areas:	
Analysis.	.84
Logical design.	.86
Standard setting.	.83
Coding/programming.	.73
Data conversion.	.76
Data administration/database management.	.74
Testing.	.78
Software change management.	.69
Project management.	.65
Software process methodology.	.74
Interfacing or linking applications together.	.79
Software quality assurance.	.81
Setting priorities and planning.	.74
Contingency planning.	.64

Risk management.	.59
Project Management (explains 32.3% of the variance)	
Percent of work time project manager is dedicated to this project.	-.03
How many months, has the project manager had this assignment?	.07
Extensive project management experience with:	
Information systems develop projects.	.09
Projects that involve many separate application systems.	.19
Projects that involve many separate business units.	.25
Application maintenance projects.	-.01
This organization has centralized control of all year 2000 date efforts	.31
This organization will have a centralized group to:	
Certify all applications.	.93
Certify all purchased applications.	.88
Certify all utility software products.	.89
Certify all replacement applications.	.94
Management Support (explains 66.2% of the variance)	
Top IS management ______________________the year 2000 date problem.	
Strongly supports and is committed to solving	.80
Really understands the scope (how big it is) of	.87
Really understands the potential impact (how serious it is)	.81
Top organizational management ______________________the year 2000 date problem.	
Strongly supports and is committed to solving	.80
Really understands the scope (how big it is) of	.82
Really understands the potential impact (how serious it is)	.83
Tools (explains 49.7 % of the variance)	
This organization will extensively rely on vendor's tools for external help with year 2000 date problem solutions.	.58
Computer-based tools will play a significant role in:	
Determining the scope of the problem and inventorying Applications.	.77
Conducting impact assessment.	.81
Storing and managing inventory and impact data.	.63
Planning, scheduling, budgeting and prioritizing.	.68
Converting and/or replacing code.	.71
Testing the solution.	.73
Change management.	.57
Estimating cost.	.63
Modifying data.	.74

The analysis of the items concerning project management explains only 32.3 percent of the variance and only four of the items have a loading value above .3. The four items concerning centralized group for certification of projects all have values of .8 or higher, however.

Table 3-5. **Questionnaire Items Selected To Measure The Project Stage Dimension (with factor loading values).**	
(Explains 45.1 % of the variance)	Loading
This organization:	
Is well aware of the year 2000 date problem.	.51
Has studied the year 2000 date problem, inventoried its applications, and conducted an impact analysis.	.72
Has completed an impact study to determine the exact nature of our year 2000 problem on all hardware, software, and data assets.	.76
Has detailed plan, schedules, and budgets for solving the year 2000 date problem.	.73
Has completed an inventory of all hardware, software and data assets.	.56
Has conducted pilots to validate its year 2000 budget estimates.	.69
Has already tested its year 2000 date compliance solutions(s).	.68
Has already solved the year 2000 problem at the code and data level.	.47
Has implemented and made operational its solutions(s).	.72
Has already solved the problem and is year 2000 date compliant.	.76
Estimated percent completed to date for:	
Determining scope of problem, inventorying applications, conducting an impact assessment.	.63
Planning, scheduling, budgeting, and prioritizing.	.68
Converting and/or replacing code, modifying data, replacing hardware.	.75
Testing the solutions.	.72
Making the solution operational.	.62

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Table 3-5 shows the results of the factor analysis for the items selected to measure project stage when forced into a single factor and confirms that all the items selected to measure stage are statistically valid measures. The loading values for these items are all moderate or higher, and they can collectively explain 45.1 percent of the variance.

In summary, most of the questionnaire items selected to measure the dimensions and sub-dimensions of the model are, in fact, statistically valid measures. In some cases, the items that were confirmed as valid measure do not seem to comprehensively represent all aspects of a sub-dimension or dimension; however, it is believed that the measures confirmed do provide adequate representation of the independent variables for testing each of the five hypotheses.

Analysis of All Respondents

The first step in testing each of the five hypotheses was a correlation analysis of the individual independent variables, that is the responses to the individual questionnaire items, with the dependent variable, total year 2000 project estimated cost as a percent of the organization's annual IS budget, using the data for all 187 respondents. This group was referenced as "all respondents" in the remainder of this document.

The Pearson product-moment correlation was appropriate for the analysis of the hypotheses derived from the year 2000 enterprise cost model since a correlation shows the extent of a linear relationship between two variables on a scale from zero to –1.00 or +1.00, with either extreme indicating a perfect relationship. A negative correlation indicates the variables vary inversely, and a positive relationship indicates that the two variables vary together in the same direction. It is important to note that correlations do not prove causation, but rather only that the two variables vary together. It is important that care is taken in inferring causation from correlations. Since this was an exploratory study, however, correlation of the questionnaire items selected to measure each sub-dimension or dimension and estimated percent cost was a good starting point for analysis of these relationships.

The analysis for all respondents indicated statistically significant relationships for only 26 independent variables out of a total of 144 validated measures with the dependent variable, estimated percent cost. Most of the correlations found were also low in magnitude (e.g., $r < .3$). Only two relationships were indicated with a magnitude of .3 or higher -- (1) gross revenues or income of the division in the last fiscal year ($r = .3591$, $p \leq .01$, $n = 50$, see Table 4-1) and (2) reliance on consultants for external help ($r = .3197$, $p \leq .00$, $n = 114$). See Table 4-2 through Table 4-16 for the results of the analysis of all respondents.

Analysis of Projects in the Early-Planning and Later-Planning Stages

In order to compare projects by stage, two sample groups for stage were needed. Table 3-6 presents the mean responses, on a scale of 1 to 9, for five items measuring projects stage with the percent of organizations responding six or less and the percent of organizations responding greater than 6 for each of these.

These results suggest that the majority of the year 2000 projects were engaged in planning activities at the time that the Y2K project managers completed the questionnaires. Thus, the questionnaire item selected for grouping the sample by stage was that the organization “has detailed plans, scheduled and budgets for solving the year 2000 date problem.” The early-planning stage group will include those organizations with a response of 6 or less, and the later-planning stage will include those organizations

Table 3-6. Responses For Stage Variables From All Respondents.	Mean	Percent Responding	
This organization:		≤ 6	>6
Is well aware of the year 2000 date problem	7.4	24%	76%
Has detailed plans, schedules and budgets for solving the year 2000 date problem.	6.4	48%	52%
Has conducted pilots to validate its year 2000 budget estimates	5.3	65%	35%
Has already tested its year 2000 date compliance solution(s)	3.7	83%	17%
Has implemented and made operational its solution(s) to the year 2000 problem.	2.3	87%	13%

with a response of more than 6. The results indicate that there are 83 cases in the early-planning stages group, and 96 cases in the later-planning stage group.

Analysis of Smaller and Larger IS Organizations

Because of the limited number of relationships indicated in the analysis of all respondents, further analysis of the questionnaire responses was undertaken with the respondents grouped by organization size. Research suggests (Boehm, 1981) that size is a key component in estimating costs. Project size is a fundamental element used in most rational cost estimating models, and the size of the Y2K project should directly relate to the size of the organization. Larger IS organizations should also have more practice estimating costs of projects and have the historical data required for rationally estimating costs. Thus the analysis included separation of the respondents by organization size in order to further examine the relationships of the model.

Two groups of respondents were selected based on the size of their IS operating budget, the top 40 percent and the bottom 40 percent. The frequencies generated for IS operating budget indicated that $10,000,000 was the upper limit for smaller IS organizations and that $20,000,000 was the lower limit for larger IS organizations. These groups will be referenced as the “smaller IS organizations” and the “larger IS organizations” in the remainder of this document.

Summary

This research was a field study to explore the relationships depicted in the Year 2000 Enterprise Cost Model (Figure 2 in Chapter 1) by testing five hypotheses derived from it. The research design was a field study using a survey questionnaire of year 2000 project managers from industry, government, and education, primarily SIM member organizations.

The analysis included factor analysis to confirm the individual measures selected for each dimension and sub-dimension of the model and then testing of the five hypotheses concerning the relationships indicated in the model by correlation of these items with estimated percent cost. The analysis examined the relationships of the model using five different sample groups; (1) all respondents, (2) smaller IS organizations (organizations having an IS operating budget less than $1,000,000), (3) larger IS organizations (organizations having an IS operating budget greater than $20,000,000), (4) projects in the early-planning stages (responded 6 or less to the statement “has detailed plans, schedules and budgets”), and (5) projects in the later-planning stages (responded higher than 6 on “has detailed plans, schedules, and budgets”).

CHAPTER 4

ANALYSIS AND FINDINGS

Introduction

The primary purpose of this research was to explore the relationships shown in the Year 2000 Enterprise Cost Model (Figure 2 in Chapter 1). The study examined the relationships of individual project attributes with estimated costs using a field study, specifically a survey of year 2000 project managers in industry, government, and education. This chapter presents the analysis and findings for the five hypotheses, developed from the relationships indicated in the model. The analysis and findings for an alternate hypothesis -- that the relationship varies with project stage -- was included for the other four cost influence dimensions -- organization, problem, solution, and resources.

The terminology used to represent the model and to describe the variables in the discussion of this research is shown in Table 4-1. The terms “dimension” and “construct” are synonymous in this document, as are the terms “sub-dimension” and “sub-construct.” The terms dimension and sub-dimension are used for consistency unless there was a specific reason to do otherwise. The questionnaire items selected to measure each dimension or sub-dimension of the model were the independent variables for this study. The items were validated as valid measures using factor analysis and Nunnally’s (1978) minimum factor loading criteria of .30 for including an item as part of a factor. See Chapter 3 for a description of the questionnaire item validation process. The dependent variable, estimated percent cost, as defined in Chapter 3, is the total cost of the year 2000 projects in an organization divided by its annual IS operating budget. This variable was selected because it normalizes estimated costs for the size of the IS organization and thereby makes the subject organizations comparable.

Table 4-1. The Terminology Used In This Document.

Term	Used to Reference:	Equivalent terms
Independent Variables		
1. Dimension	Any one of the six main cost influence components of the year 2000 Enterprise Model	Construct
2. Sub-dimension	The categories of cost influences within a dimension of the model	Sub-construct
3. Questionnaire item	Any item on the questionnaire that solicits a response	Independent variable
4. Variable	Can be either a questionnaire item or a calculated measure derived from 2 or more items.	
Dependent Variable		
5. Estimated percent cost	The calculated variable – total estimated costs of year 2000 projects in an organization divided by its annual IS budget	Dependent variable

The analysis first consisted of correlations of the dependent variable with the measures validated measures to operationalize the dimensions of the model for each hypothesis. Because only a limited number of relationships were indicated in the analysis of all respondents, further analysis included examination of the independent variables with respondents grouped by IS organization size. Two size groups were selected from the data set based on the annual IS operating budget for the organization, the top 40 percent and the lowest 40 percent. The justification for the examination by IS organization size was that larger IS organizations are more likely to use rational cost estimating models because these organizations would be more likely to have the historical data required by most models (Boehm, 1981; Lederer & Prasad, 1995a, 1995b; Giles & Barney, 1995). The level of technology use in of these organizations should also be higher. If these assumptions are true, larger IS organizations should be able to more accurately estimate project costs and be the group that the model would best represent.

For testing the alternate hypotheses, that the relationships represented in the model differ by project stage, the analysis divided the respondents into two groups based on responses to the questionnaire item that this organization "has detailed plans, schedules, and budgets for solving the year 2000 date problem." Projects for which the project managers responded 6 or less (on a scale of one to nine with five being a neutral response) were considered in to be in the early-planning stages, and those for which the project manager responded higher than 6 were considered to be in the later-planning stages. Thus, the analysis included correlations between estimated percent cost and the five other dimensions of the model with the independent variables operationalized by individual questionnaire items for five different groups: (1) all respondents, (2) larger IS organizations (annual IS operating budget greater than $20,000,000), (3) smaller IS organizations (annual IS operating budget less than $10,000,000), (4) projects in the early-planning stages, and (5) projects in the later-planning stages.

The first table shown for each hypothesis includes the correlations for all the individual independent variables tested for all respondents and for larger IS organizations, since this analysis group should be the most likely to use cost estimating processes and procedures. A separate table then presents the correlations for smaller IS organizations followed by a table with the findings for projects in the early-planning and later-planning stages. The tables for smaller IS organizations and by project stage will include only the items for which relationships were indicated rather than all the valid independent variable items. As stated in Chapter 3, a correlation with a strength of .3 or greater will be considered indicative of a moderate relationship. Relationships having a 90 percent confidence level or higher ($p \leq .10$) will be considered statistically significant. A 90 percent confidence level is acceptable because this was exploratory research. Regardless of the strength of the relationship, statistically significant relationships are noted in bold in the tables.

The first criteria used for rejecting the null hypothesis, that there is no relationship, was that there must be more statistically significant relationships indicated than would occur randomly. Since correlations with a 90 percent confidence level ($p \leq .10$) are considered to be statistically significant in this study, random occurrence can explain relationships for 10 percent of the independent variables selected to measure a dimension or a sub-dimension. Hence, the following scale was used initially to rank the strength of the evidence for rejecting the null hypothesis for a sub-dimension or dimension:

Random	1-10%
Very weak	11-20%
Weak	21-30%
Moderate	31-40%
Moderately strong	41-50%
Strong	51% or higher

When the percentage of relationships indicated for the independent variables for a sub-dimension or dimension fell below 20 percent, the strength of evidence was considered very weak and deemed questionable. Two subjective weighting considerations were taken into account as well as the percent of relationships found. The first was that relationships for some independent variables, particularly those that broadly assess presence of a sub-dimension, were weighted more heavily than variables that measure a very specific attribute of a sub-dimension. The second weighting was for the magnitude of the relationships. These two subjective weightings were used sparingly and only in instances where there were considerable differences in the level of measures or in the magnitude of the correlations.

Hypothesis 1: Organization

The null hypothesis identified for testing the relationship between organizational characteristics and estimated percent cost in the Year 2000 Enterprise Cost Model is:

> **H1: There is no relationship between organizational characteristics and estimated costs of year 2000 compliance projects as a percent of annual IS budget.**

As shown in the model, there are three sub-dimensions of cost influences within the organization dimension: size, IS practices, and industry. There were nine independent variables measuring size and thirty measuring IS practices. Correlations were appropriate for testing for a relationship between the dependent variable (estimated percent cost) and the independent variables for size and IS practices, since these variables contain interval values. There were two questionnaire items measuring industry, parent industry and division industry, but both contain categorical responses. Thus the analysis for the industry sub-dimension consisted of grouping responses by industry and testing for a difference in means for the groups. The analysis of industry also included discriminant analysis to determine if industry group could be predicted from estimated percent cost.

Size

Table 4-2 presents the correlations for the nine independent variables validated to measure size from the analysis of all respondents and for larger IS organizations. Support for a relationship between size and cost in the analysis of all respondents was weak since only three of the nine independent size variables have a statistically significant correlation with estimated costs. The findings indicated a positive relationship for division revenue ($r = .3591$, $p \leq .01$, $n = 50$) and negative relationships for the number of people working in the parent organization ($r = -.1679$, $p \leq .06$, $n = 125$) and IS operating budget ($r = -.1659$, $p \leq .06$, $n = 126$). The analysis of projects in the later-planning stages also indicated a relationship between division revenue and estimated costs ($r = .4850$, $p \leq .01$, $n = 26$) with a magnitude somewhat higher than the correlation from all respondents, although the sample size was smaller. The survey questionnaire asked respondents to identify their reporting level within the organization, division or parent, on the survey and then asked them to include the corresponding division and/or parent revenue and number of people working in the organization. Hence the number of respondents in the group reporting division revenue was small relative to number of respondents for the other items. It is reasonable that the estimated costs for Y2K projects would relate positively to division revenue, but the negative relationships indicated for the number of people in the parent organization in larger IS organizations is not as easily explained. Its magnitude was low; so the indication of this relationship may be merely a random occurrence.

<u>Table 4-2.</u> Correlation Indicated Between Organization Size Measures and Estimated Costs as a Percent of Annual IS Budget for All Respondents and for Larger IS Organizations.						
	All Respondents			Larger IS Organizations		
	r	<u>*p*≤</u>	*n*	*r*	<u>*p*≤</u>	*n*
What were the gross revenues or income of the division in the last fiscal year?	**.3591**	**.01**	**50**	.0205	.93	19
How many people work in your division?	-.1158	.40	55	.0157	.95	22
What were the gross revenues or income of the parent organization in the last fiscal year?	-.1177	.20	119	-.1070	.46	51
How many people work in your parent organization?	**-.1679**	**.06**	**125**	-.1882	.17	56
What was the total operating budget of this IS organization during the last fiscal year?	**-.1659**	**.06**	**126**	-.1946	.15	56
How many people work for this IS organization?	-.1347	.13	126	-.1681	.22	55
How many total lines of code (in thousands) are in your organization?	-.1347	.23	81	-.1572	.31	43
How many software applications are in your organization?	-.0305	.76	102	**.2528**	**.10**	**43**
How many separate data files are in your organization?	-.0630	.66	50	-.3006	14	.28

The analysis for a relationship for size and estimated costs in larger IS organizations indicated no evidence of support that could not be explained by random occurrence, and the evidence in smaller IS organizations was very weak. Although only two of the nine size measures have a statistically significant correlation with estimated percent cost in smaller IS organizations, both of the relationships indicated were positive and of moderate magnitude. Table 4-3 shows that size in smaller IS organizations, measured by how many people work for the IS organization (r = .4094, $p \leq .01$, n = 41) and the total lines of code in the organization (r = .5939, $p \leq .01$, n = 17), related positively with estimated percent cost. Since significant relationships were not indicated for these variables in larger IS organizations, these findings may indicate that IS staff size and lines of code are an influence “up to a point”; but, that once a certain size is reached, these variables may no longer matter. The number of applications in the organization (r = .2528, p = .10, n = 43) may possibly be a more important influence on estimated costs for larger IS organizations.

Table 4-3. Statistically Significant Correlation Indicated Between Organization Size Measures and Estimated Costs as a Percent of Annual IS Budget for Smaller IS Organizations.

Questionnaire Items	r	$p \leq$	n
How many people work for this IS organization?	**.4094**	**.01**	**41**
How many total lines of code are in your organization?	**.5939**	**.01**	**17**

Interestingly in testing H1 for the sub-dimension of size, relationships for nine individual independent variables were examined in five different sample groups, and there was sufficient evidence to reject the null hypothesis for this sub-dimension. The strength of the evidence supporting a relationship for size overall was very weak. The strongest evidence found, which was weak, comes from all respondents with relationships indicated for three of the nine size measures (33%). The analysis indicated statistically significant correlations of moderate magnitude (r = .3 or higher) for only three questionnaire items: (1) division revenue in the analysis of all respondents and for projects in the later-planning stages, (2) number of IS people in smaller IS organizations, and (3) total lines of code in the smaller IS organizations. The limited findings may suggest further research. It is possible that there is colinearity or some other statistical noise in the data as well.

IS Practices

Table 4-4 presents the correlations for the thirty questionnaire items validated to measure IS practices from the analysis of all respondents and for larger IS organizations. The relationships found for IS practices for all respondents can be explained by random occurrence. There were three statistically significant relationships indicated, but the correlations were all low in magnitude as well as low in number. The three relationships indicated for all respondents were that the organization uses a combination of estimating methods ($r = .1714$, $p \leq .07$, $n = 110$) and uses a comprehensive set of processes and procedures for continuous process improvement ($r = -.1702$, $p \leq .06$, $n = 124$) and for continuous productivity improvements ($r = -.2437$, $p \leq .00$, $n = 125$).

Table 4-4. Correlation Indicated Between IS Practices and Estimated Costs as a Percent of Annual IS Budget for All Respondents and for Larger IS Organizations.

	All Respondents			Larger IS Organizations		
This IS organization:	*r*	*p*≤	*n*	*r*	*p*≤	*n*
Has a comprehensive and tested IS disaster recovery plan.	-.0750	.40	127	-.2158	.11	56
Does extensive benchmarking to other IS organizations.	-.0587	.52	120	**-.3110**	**.02**	**53**
Has a clearly defined and utilized software process methodology for:						
1. IS development.	-.0986	.27	125	**-.3419**	**.01**	**56**
2. Application maintenance (i.e. minor changes).	.0247	.78	128	**-.2575**	**.06**	**56**
3. System conversion (i.e. large-scale changes).	-.1135	.20	128	**-.3109**	**.02**	**56**
4. Change management (keeping track of versions, maintenance and conversions.	-.0024	.98	126	-.0772	.58	55
Encourages project managers to recommend that software projects be terminated if they deserve to be.	-.0176	.85	126	.0262	.85	55
Encourages everyone on the project team to recommend that software projects be	-.0340	.71	126	-.0833	.55	55

terminated if they deserve to be.						
Cost estimating for IS projects is based primarily on these metrics:						
1. number of lines of code.	-.0891	.41	87	**-.3729**	**.02**	**38**
2. function points.	-.0550	.61	90	-.0514	.76	39
Cost estimating for IS projects is based primarily on these estimating methods:						
1. Top-down.	.0675	.55	81	-.1691	.32	37
2. Bottom-up.	.1177	.30	79	**-.4738**	**.00**	**35**
3. Historical data.	.1631	.12	94	.1159	.48	39
4. A combination of these.	**.1714**	**.07**	**110**	-.0539	.72	46
For software development and/or maintenance, this organization specifies and uses a comprehensive set of processes and/or procedures for:						
1. Establishing customer agreement on requirements.	.0581	.52	124	-.2056	.14	54
2. Estimating all resource needs.	-.0382	.67	124	-.1903	.17	54
3. Tracking progress and resource use.	.0163	.86	125	-.0351	.80	55
4. Selecting, contracting, tracking and reviewing software contractors/outsourcers.	-.0091	.92	122	-.2076	.13	55
5. Software quality assurance.	-.0970	.28	125	**-.2451**	**.07**	**55**
6. Continuous process improvement.	**-.1702**	**.06**	**124**	**-.2939**	**.03**	**55**
7. Identifying the training needs of IS professionals.	.0012	.99	125	-.1644	.23	55
8. Tailoring the process to project-specific needs.	-.0173	.85	124	-.0396	.77	55
9. Coordination and communication among development groups.	-.0896	.33	123	-.2188	.11	55
10. The examination of work products by peers.	-.0954	.29	123	**-.3495**	**.01**	**55**
11. Measuring project progress.	-.0545	.55	125	**-.3082**	**.02**	**55**
12. Establishing quality goals with customers.	-.0555	.54	124	-.1406	.31	55
13. Analyzing problems and preventing re-occurrence.	-.1028	.25	125	-.1306	.34	55
14. Evaluating new technologies and utilizing when appropriate.	-.0979	.28	124	**-.3234**	**.02**	**55**
15. Continuous productivity improvements.	**-.2437**	**.00**	**125**	**-.2438**	**.07**	**55**
16. Unit, system, acceptance and regression testing.	.0158	.86	124	-.0994	.48	54

The analysis of larger IS organizations indicated moderate evidence to support a relationship between IS practices and estimated costs with statistically significant negative correlations indicated for 12 of the 30 variables measuring IS practices. As Table 4-4 shows, eight of these were moderate or higher (r = .3 or higher) in magnitude. The relationships indicated as significant were also consistently negative; supporting the idea that use of superior IS practices do mean lower estimated costs.

Perhaps as important as the number of the relationships found were what relationships were indicated. The significant relationships fall into four categories, covering the use of software process methodologies, estimating method, quality control, and project management. Three of the relationships indicated that a high-level use of a software process methodology might decrease costs. The analysis indicated relationships for the independent variables measuring use of software process methodologies for (1) IS development ($r = -.3419$, $p \leq .01$, $n = 56$), (2) application maintenance ($r = -.2575$, $p \leq .06$, $n = 56$), and (3) system conversion ($r = -.3109$, $p \leq .02$, $n = 56$). Extensive benchmarking with other IS organizations ($r = -.3110$, $p \leq .02$, $n = 53$) and two of the variables measuring estimating practices, that cost estimating was based primarily on the number of lines of code ($r = -.3729$, $p \leq .02$, $n = 38$) and that cost estimating was based primarily on the bottom-up method ($r = -.4738$, $p \leq .00$, $n = 35$), indicated possible negative relationships with estimated percent cost. The last three relationships indicated were for questionnaire items concerning processes or procedures recommended from the SEI CMM model; (1) examination of work product by peers ($r = -.3495$, $p \leq .01$, $n = 55$), (2) measuring project progress ($r = -.3082$, $p \leq .02$, $n = 55$), and (3) evaluating new technologies and utilizing when appropriate (*r* = -.3234, *p* ≤ .02, *n* = 55).

Table 4-5. Statistically Significant Correlation Indicate Between IS Practices and Estimated Costs as a Percent of Annual IS Budget for Smaller IS Organizations.			
Questionnaire Items	*r*	*p*≤	*n*
This IS organization encourages project managers to recommend that software projects be terminated if they deserve to be.	**-.4106**	**.01**	**41**
For software development and/or maintenance this IS organization specifies and uses a comprehensive set of processes and/or procedures for:			
Coordination and communication among development groups.	**-.4116**	**.01**	**39**
Analyzing problems and preventing re-occurrence.	**-.3601**	**.02**	**41**
Continuous productivity improvements.	**-.3400**	**.03**	**41**

The analysis of the smaller IS organizations indicated relationships for four variables measuring IS practices, and provided very weak support for a relationship between IS practices and estimated costs. As Table 4-5 shows, the statistically significant relationships found were negative, moderate or higher in magnitude, and below the .05 significance level. The first, that the organization encourages project managers to terminate project that deserve it (*r* = -.4106, *p* ≤ .01, *n* = 41), may be a function of organization size to some degree. The Y2K project managers in smaller organizations would be more likely to have complete control of projects and have a closer working relationship with upper management; thus, they would get more support for canceling projects. Smaller IS organizations simply may not have the capital to carry on with projects that are not going well. The other three relationships indicated were for SEI CMM practices; (1) coordination and communication among development groups (*r* = -.4116, *p* ≤ .01, *n* = 39), (2) analyzing problems and preventing re-occurrence (*r* = -.3610, *p* ≤ .02, *n* = 41), and (3) continuous productivity improvements (*r* = -.3400, *p* ≤ .03, *n* = 41). Of these three, the only relationship indicated in both smaller and larger IS organizations was for continuous productivity improvements.

What may be as interesting as the relationships indicated for smaller IS organizations were the relationships not found to be significant. No relationships were indicated between estimated percent cost and the responses to the questions that the organization has a clearly defined and utilized software process methodologies. Do these missing relationships possibly indicate that smaller IS organizations do not have clearly defined software process methodologies or do they simply indicate that these methodologies do not influence estimated percent cost?

In summary, there was ample evidence to reject the null hypothesis for the IS practices sub-dimension. The findings from larger IS organizations provided moderate support, using the established rating scale, with relationships indicated for 12 of the 30 measures (40%) for IS practices. Weak evidence was found for smaller organizations; but, interestingly, there was little support for rejection found in projects in the analysis of all respondents. Although the direction of a correlation does not effect the rejection decision, the fact that the correlations for IS practices were all negative indicated that these relationships were not random occurrences. A history of superior IS practices appear to mean lower percent estimated costs for year 2000 projects, particularly for projects in larger IS organizations and projects in the early-planning stages.

Industry

Since the variables for industry are not interval, the respondents were grouped by their responses for industry into five categories, (1) business, (2) service industries, (3) manufacturing/production, (4) government, and (5) other industries. The analysis included t-tests to compare the means for estimated percent cost for all combinations of industry groups and discriminant analysis to determine if industry group could be predicted from estimated percent cost. The t-test results indicated a significant difference between means in only two group comparisons: (1) the comparison of the manufacturing/production and government groups, and (2) the comparison of the government and other groups. The results of discriminant analysis indicated that the industry group could be predicted overall in only 28 percent of the cases, but in 55.6 percent of the government cases and in 79.3 percent of the other industry cases. The validity of these findings was weak since there were only nine government respondents and the other industry group was not a logically homogeneous group.

Summary of Hypothesis 1 Findings

The analysis found sufficient evidence to reject the null hypothesis concerning organization, on the basis of the moderate ratings for the evidence found supporting a relationship for IS practices in larger IS organizations (40%) and in projects in the early-planning stages (33%). Most of the correlations indicated were moderate or lower in magnitude for these groups, however. There was no substantial evidence to reject the null hypothesis from all respondents or from projects in the later-planning stages. The evidence suggests that IS practices may have a stronger influence in large organizations and that IS staff size may be stronger influence in smaller IS organizations. The strongest evidence to reject this null hypothesis was the relationships for the responses to the statements concerning the use of high-level software process methodologies and estimated percent cost in projects in larger organizations and in projects in the early-planning stages.

Hypothesis 1A: Organization by Project Stage

The null hypothesis for testing whether the relationships between organizational characteristics and percent estimated costs varies with project stage was:

> **H1A: There is no relationship between organizational characteristics and estimated costs for year 2000 compliance projects as a percent of annual IS budget when moderated by project stage.**

The findings for IS practices indicated strong support that the relationship between organization and estimated costs varies by project stage, but the findings for size did not provide any additional support. The analysis of projects in the early-planning stages indicated no relationships for size variables and 10 relationships for independent variables measuring IS practices. The analysis of projects in the later-planning stages indicated a relationship for only one size measure, division revenue (r = .4843, $p \leq .01$, n = 26) and no relationships for variables measuring IS practices.

The analysis of Y2K projects in the early-planning stages (see Table 4-6) indicated statistically significant negative correlations between estimated percent cost and ten of the measures for IS practices. The relationships from this group were consistent to a large degree with the findings from larger IS organizations in magnitude and direction. Negative relationships were indicated for benchmarking (r = -.3523, $p \leq .01$, n = 53), software process methodologies for IS development (r = -.3029, $p \leq .03$, n = 54), for system conversion (r = -.4027, $p \leq .00$, n = 56), and for the SEI CMM recommended practices of (1) continuous process improvement (r = -.4715, $p \leq .00$, n = 54) and (2) examination of work by peers (r = -.3154, $p \leq .02$, n = 55). The relationship indicated for use of a software process methodology for application maintenance (r = -.3343, p < .01, n = 56) and estimated percent cost was statistically significant for projects in the early planning stages as it was in larger IS organizations, but its magnitude was higher in this analysis. It is noteworthy that the relationships indicated for three SEI CMM

Table 4-6. **Statistically Significant Correlation Indicated Between Organizational Characteristics and Estimated Costs as a Percent of Annual IS Budget by Project Planning Stage.**

		Early-Planning Stage Projects			Later-Planning Stage Projects		
Size:		*r*	*p*≤	*n*	*r*	*p*≤	*n*
	What were the gross revenues or income of the division in the last fiscal year?	-.0174	.94	22	**.4843**	**.01**	**26**
IS Practices							
	This IS organization does extensive benchmarking to other IS organizations.	**-.3523**	**.01**	**53**	.0592	.64	64
	Has a clearly defined software process methodology for:						
	IS development.	**-.3029**	**.03**	**54**	-.0271	.83	68
	Application maintenance.	**-.3343**	**.01**	**56**	.0838	.50	68
	System conversion.	**-.4027**	**.00**	**56**	.0011	.99	68
	Cost estimating for IS projects is based primarily on the bottom-up estimating methods.	**-.3174**	**.06**	**35**	**.3136**	**.04**	**43**
	Process and/or procedures for:						
	Software quality assurance.	**-.2951**	**.03**	**55**	.0262	.84	66
	Continuous process improvement.	**-.4715**	**.00**	**54**	.0056	.97	66
	The examination of work products by peers.	**-.3154**	**.02**	**55**	-.0072	.96	65
	Establishing quality goals with customers.	**-.3281**	**.01**	**55**	.0695	.58	66
	Continuous productivity improvements.	**-.5065**	**.00**	**55**	-.0930	.46	66

practices move from near significance in larger IS organizations to become significant in projects in the early-planning stages: (1) software quality assurance (r = -.2951, $p \leq .03$, n = 55), establishing quality goals with customers (r = -.3281, $p \leq .01$, n = 55), (3) continuous productivity improvements (*r* = -.5065, $p \leq .00$, *n* = 55).

The analysis of projects in the later-planning stage indicated a possible relationship for only one IS practices, that cost estimating for IS projects was based primarily on the bottom-up estimating methods (*r* = .3136, $p \leq .04$, *n* = 43). There was a conflicting direction in the relationships found for use of the bottom-up estimating method between groups. It was positive for projects in the later-planning stages but negative in projects in larger IS organizations (*r* = -.4738, $p \leq .00$, *n* = 35) and in projects in early-planning stages (*r* = -.3174, $p \leq .06$, *n* =35). Bottom-up estimating appears to decrease estimated percent cost in projects in the early-planning stages and in larger organizations but increases estimated percent cost in projects in the later-planning stages.

In summary, the difference in the number of relationships indicated for the size and IS practices sub-dimensions and the change of direction of the relationship for bottom-up estimating in later planning stage projects provided sufficient evidence to reject the null hypothesis. These findings were inconsistent with the literature to some degree, however. IS practices should be as important, if not more so, during the later-planning stages than in the early-planning stages. A possible explanation is that mangers of Y2K projects that have progressed into the later stages should have had IS practices in place for some time and may be simply focusing on the tasks at hand rather than on IS practices. Conversely, IS practices may not influence costs as much as initially thought.

Hypothesis 2: Problem

The null hypothesis identified for testing the relationship between the year 2000 problem characteristics and estimated costs as a percent of annual IS budget is:

H2: There is no relationship between year 2000 problem characteristics and estimated costs of year 2000 compliance projects as a percent of annual IS budget.

As indicated in the Year 2000 Enterprise Cost Model, there are three sub-dimensions within the problem dimension of the model: (1) awareness, (2) impact, and (3) complexity and scope. Although complexity and scope are separate sub-dimensions in the model, the questionnaire items validated to measure complexity and scope from the survey do not adequately distinguish between complexity and scope. Thus, this research will treat complexity and scope as a single sub-dimension. There were eight independent variables measuring awareness, five measuring impact, and seven measuring complexity and scope.

Awareness

The analysis indicated very weak evidence to support a possible relationship between level of awareness and estimated costs for each of the analysis groups except for projects in the later-planning stages. As Tables 4-7 through 4-8 present, only two of the eight questionnaire items measuring awareness indicated a statistically significant relationship with estimated percent cost in any of the analyses. A positive relationship was indicated for responses to the questionnaire item that the respondent closely follows the year 2000 date problem in the media in the analysis of all respondents (r = .2129, $p \leq .02$, n = 128) and in the analysis of smaller IS organizations (r = .3171, $p \leq .04$, n = 42), with a somewhat larger magnitude in smaller IS organizations.

<u>Table 4-7</u>. Correlation Indicated Between Problem Characteristics and Estimated Costs as a Percent of Annual IS Budget for All Respondents and for Larger IS Organizations.						
	All Respondents			Larger IS Organizations		
Awareness	*r*	*p*≤	*n*	*r*	*p*≤	*n*
Regarding the year 2000 date problem in my organization:						
I closely follow this issue in the media.	**.2129**	**.02**	**128**	.1454	.29	56
I regularly attend workshops or conference about this.	.1052	.24	125	.1291	.34	56
This organization:						
Is well aware of the Y2K date problems.	.0467	.60	128	-.0890	.51	56
Has had significant discussions of the year 2000 date problem with its:						
Customers.	-.0628	.51	115	-.1069	.45	52
Suppliers.	-.0794	.40	118	-.0579	.68	54
Internal users.	.0038	.97	127	-.0728	.59	56
Trading partners.	-.0839	.40	104	-.1096	.45	49
Software and hardware vendors.	-.0516	.57	123	**-.4762**	**.00**	**54**
Impact						
It will significantly impact our competitive advantage.	-.0865	.34	126	.0500	.71	56
It will significantly impact our ability to serve our customers/citizens.	-.0279	.76	126	.1413	.30	56
This is not a serious problem in this organization.	**-2306**	**.01**	**122**	**-.2458**	**.07**	**55**
The year 2000 date problem will have a significantly negative effect on my organization.	**.2353**	**.01**	**99**	**.2446**	**.08**	**54**
The year 2000 date problem will have no impact whatsoever on this organization.	**-.1914**	**.03**	**123**	**-.2898**	**.03**	**55**
Complexity and Scope						
Percentage of lines of code affected.	-.1156	.32	75	.0717	.67	37
Percentage of applications to replace.	**.1604**	**.09**	**111**	-.0907	.54	48
Percentage of data files to modify.	-.0651	.59	71	.1288	.53	26
Percentage of screens and reports to modify.	-.0831	.48	75	.2254	.24	29
Percentage of source code missing.	-.0562	.59	96	-.0549	.72	44
Percentage of hardware to upgrade or replace.	**.1826**	**.08**	**91**	**.3132**	**.06**	**37**
Percentage of system software and utilities to be upgraded or replaced.	**.2637**	**.01**	**89**	**.3002**	**.06**	**39**

Responses to the statement that this organization has had significant discussions of the year 2000 date problem with its software and hardware vendors indicated a negative relationship of moderate magnitude in the analysis of all respondents (r = -.4762, $p \leq .00$, n = 54) and in projects in the early-planning stages (r = -.2914, $p \leq .03$, n = 56) with a lower magnitude. The negative direction of this relationship supports the idea that solving the year 2000 problem is a global effort. This finding suggests that, as discussions with software and hardware vendors increase, estimated percent cost goes down. Based on the findings of no more than one relationship in any analysis group for independent variables measuring awareness, there was very weak evidence at best to reject the null hypothesis for the awareness sub-dimension.

Impact

There was strong evidence for support of a possible relationship between degree of potential impact and estimated percent cost, based on the number of relationships indicated for all respondents and for larger IS organizations. The magnitude of all the correlations was relatively low, however. As shown in Tables 4-7 through 4-9, five questionnaire items were selected to measure the impact sub-dimension. Three of these, that the year 2000 problem (1) was a serious problem in this organization, (2) will have a significantly negative effect on this organization and (3) will have no impact whatsoever; correlated with estimated percent cost in the analysis of all respondents and in larger IS organizations. The direction of each of these was appropriate to the perspective of the question, indicating that increased impact means higher estimated costs. The analysis of smaller IS organizations indicated no relationships for variables measuring impact, however. These differences may be explained simply by the fact that the impact should be greater for larger IS organizations because they are likely to be more information intensive and have more complex systems.

<u>Table 4-8.</u> Statistically Significant Correlation Indicated Between Problem Characteristics and Estimated Costs as a Percent of Annual IS Budget for Smaller IS Organizations.			
Awareness	*r*	$p \leq$	*n*
As project manager, I closely follow the year 2000 date problem issue in the media.	**.3171**	**.04**	**42**
Complexity and Scope			
Planned percentage of hardware to upgrade or replace.	**.4416**	**.01**	**32**

<u>Complexity and Scope</u>

The analysis indicated possible relationships for three of the seven questionnaire items measuring complexity and scope in at least one of the analyses. As Table 4-7 presents, there were three relationships indicated in the analysis of all respondents, but the correlations for all three were very low in magnitude. Hardware seems to be the key to the influence of complexity and scope in this study, since two of the relationships indicated concern hardware. The magnitude of the correlations indicated for the items concerning hardware, the percentage of hardware to upgrade or replace (r = .3132, $p \leq$ .06, n = 39) and the percentage of software and utilities to be upgraded or replaced (r = .3002, $p \leq$ .06, n = 39), was higher in larger IS organizations. However, the magnitude of the relationship indicated for the percentage of software and utilities to be upgraded or replaced (r = .3755, $p \leq$ .01, n = 50) was even higher in projects in the later-planning stages. Likewise the magnitude of the relationship between the percent of hardware to upgrade or replace (r = .4416, p < .01, n = 32) and estimated percent cost was higher in smaller IS organizations than in larger IS organizations.

Summary of Hypothesis 2 Findings

The analyses indicated sufficient evidence to reject the null hypothesis that there is no relationship between the characteristics of the Y2K problem and estimated costs on the basis of the findings for impact and for complexity and scope, with the strongest evidence coming from larger IS organizations. The highest rating of the evidence, using the rating criteria defined earlier in this chapter, found was very weak to support a relationship for awareness, strong (60% for all respondents and for larger IS organizations) for a relationship for impact, and moderately strong (43% for all respondents) for a relationship for complexity and scope. The findings indicated significant relationships in at least one of the analysis groups for two of the eight variables measuring awareness, three of the five variables measuring impact, and three of the seven variables measuring complexity and scope.

Hypothesis 2A: Problem by Project Stage

The null hypothesis for testing that the relationship between the year 2000 problem and estimated percent cost varies by stage is:

> **H2A: There is no relationship between year 2000 problem characteristics and estimated costs of year 2000 compliance projects as a percent of IS budget when moderated by project stage.**

The analysis of projects in the early-planning stages indicated a statistically significant relationship between only one questionnaire item concerning awareness, that the organization has had significant discussions with its software and hardware vendors (r = -.2914, $p \leq .03$, n = 56); and there were no relationships indicated for awareness in the analysis of projects in the later-planning stages.

Table 4-9. Statistically Significant Correlation Indicated Between Problem Characteristics and Estimated Costs as a Percent of Annual IS Budget When Moderated by Project Planning Stage.						
	Projects in Early-Planning Stages			Projects in Later-Planning Stages		
Awareness	*r*	*p*≤	*n*	*r*	*p*≤	*n*
This organization has had significant discussions of year 2000 date problem with its software and hardware vendors.	**-.2914**	**.03**	**56**	.0536	.67	65
Complexity and Scope						
Percentage of system software and utilities to be upgraded or replaced.	.0666	.70	37	**.3755**	**.01**	**50**

The analysis of year 2000 projects in the later-planning stage indicated only one relationship from the complexity and scope sub-dimension, the estimated percent of system software and utilities that will need to be upgraded or replaced (r = .3755, p < .01, n = 50), and estimated percent cost; and there were no relationships indicated for complexity and scope in projects in the early-planning stages. Although both significant relationships found provided support for similar relationships found in the analysis of larger IS organizations, the differences were not sufficient to reject the null hypothesis that there is no relationship between problem characteristics and estimated percent cost when moderated by project stage.

Hypothesis 3: Solution

The null hypothesis to test the relationship between the year 2000 project solution characteristics and estimated costs as a percent of annual IS budget is:

> **H3: There is no relationship between year 2000 solution characteristics and estimated costs of year 2000 compliance projects as a percent of annual IS budget.**

Twenty valid questionnaire items were validated to measure the solution dimension. As Table 4-10 shows, the analyses indicated possible relationships for four items in the analysis of all respondents, one for larger IS organizations, and one for smaller IS organizations. All the relationships indicated have correlations with low magnitudes, however, except for the one found in smaller IS organizations.

Two of the relationships indicated for all respondents concern solving early -- that the organization has already solved the problem at the code and data level (r = -.2004, $p \leq$ = .03, n = 121) and have already solved the problem and is year 2000 compliant (r = -.2196, $p \leq$ = .02, n = 122). Solving early may be a key for reducing costs, but organizations that solved early may simply have had smaller or less complex projects.

Three negative relationships indicated in the analyses concern the confidence of project managers for solving the projects as planned. The confidence of Y2K project managers for being complaint with time to spare correlated with estimated percent cost in all respondents (r = -.2208, $p \leq$ = .01, n = 128) and for larger IS organizations (r = -.2271, $p \leq$ = .10, n = 55). In smaller IS organizations, the confidence of Y2K project managers for becoming complaint within the moneys budgeted correlated with estimated percent cost (r = -.4722, $p \leq$ = .00, n = 39). This relationship was the only one indicated for solution with a magnitude of at least .3 or higher.

<u>Table 4-10.</u> Correlation Indicated Between Solution Characteristics and Estimated Costs as a Percent of Annual IS Budget for All Respondents and For Larger IS Organizations.

	All Respondents			Larger IS Organizations		
This organization:	*r*	*p*≤	*n*	*r*	*p*≤	*n*
Has studied the year 2000 problem, inventoried its applications, and conducted an impact analysis.	.0544	.54	128	.0494	.72	56
Has completed an inventory of all hardware, software, and data assets.	.0454	.61	127	-.0232	.87	56
Has completed an impact study to determine the exact nature of our year 2000 problem on all hardware, software, and data assets.	.0289	.75	123	.0462	.74	53
Takes year 2000 date compliance into consideration in all new outsourcing and contract agreements.	.0353	.69	127	-.0346	.80	55
Takes year 2000 date compliance into consideration in all new licensing agreements.	-.0153	.86	127	-.1564	.25	55
Has year 2000 date compliance covered in all existing outsourcing and contracting agreements.	-.0414	.65	121	-.1078	.45	53
Has year 2000 date compliance covered in all existing licensing agreements.	-.0262	.77	124	.0363	.80	53
Has established standards for year 2000 date compliance.	.1037	.25	125	.0415	.77	54
Has detailed plans, schedules, and budgets for solving the problem.	.0847	.35	128	.0336	.81	56
Has conducted pilots to validate its year 2000 budget estimates.	.0400	.67	119	-.1141	.41	54
Already solved the problem at the code and data level.	**-.2004**	**.03**	**121**	-.1921	.16	55
Already tested its compliance solutions(s).	-.1077	.24	123	-.0675	.62	56
Implemented and made operational its solutions(s).	-.0806	.38	120	-.1123	.41	55
Has already solved the problem and is year 2000 compliant.	-.2196	.02	122	-.1840	.19	53

Has organization-wide definitions and standards for year 2000 date compliance.	.0057	.95	121	-.0128	.93	53
Has conducted a business risk assessment in order to uncover any year 2000 exposure.	.0253	.78	125	.0050	.97	55
Has prioritized projects according to the findings of business risk assessment.	.0121	.89	123	.0250	.86	54
Has curtailed spending on other projects to provide resources.	**.2028**	**.02**	**125**	.2165	.12	54
I am confident that we will be year 2000 date compliant with time to spare.	**-.2208**	**.01**	**128**	**-.2271**	**.10**	**55**
I am confident that we will become year 2000 date compliant with money to spare.	-.0439	.63	125	-.0926	.50	55

One solution-related questionnaire item, that the organization has curtailed spending on other projects to provide resources for Y2K (r = .2028, $p \leq$ .02, n = 125), correlated positively with estimated percent costs in the analysis of all respondents. This implies a scarcity of resources, a high level of commitment, and/or a great risk of impact on the organization. Thus having to use funds budgeted for other projects may be dependent on large year 2000 project costs, rather than the other way around.

Table 4-11. Statistically Significant Correlation Indicated Between Solution Characteristics and Estimated Costs as a Percent of Annual IS Budget for Smaller IS Organizations.

	r	$p\leq$	n
I am very confident that we will become year 2000 date compliant within the amount of moneys budgeted.	**-.4722**	**.00**	**39**

The analysis of respondents from the smaller IS organizations indicated statistically significant correlations for the confidence of Y2K managers for being compliant within moneys budgeted (r = -.4722, $p \leq$ .00, n = 39). The negative correlation for confidence in achieving compliance within budget may indicate that confidence was based on knowledge of the problem and its solution, possibly that these organizations are dealing with compliance solutions more efficiently and more effectively, or possibly that their problems were relatively smaller and less significant. This finding may likewise indicate that managers are simply overconfident that their budgets will be sufficient.

In summary, this research did not provide enough evidence to reject the null hypothesis that there was not a relationship between estimated costs and solution. The evidence found can be explained as a random occurrence in all of the analysis groups except for projects in the early-planning stages, in which the evidence was rated very weak with relationships indicated for four of the 20 solution measures (20%). The Y2K problem may be the primary influence for solution and may determine the subsequent influence of solution on estimated costs**.** Relationships were indicated in at least one of the analysis groups for five of the twenty measures, and most relationships occur in more than one group, although the results of each were somewhat different. The items in the questionnaire to measure the solution dimension were limited, however, and primarily address progress toward a solution rather than problem content.

Hypothesis 3A: Solutions by Project Stage

The null hypothesis for testing whether the relationship between the year 2000 solution characteristics and estimated percent cost varies by project stage was:

> **H3A: There is no relationship between year 2000 solution characteristics and estimated costs of year 2000 compliance projects when moderated by project stage.**

There was no evidence to reject this null hypothesis since the analysis indicated no relationships for solution in either of the project stage groups.

Hypothesis 4: Resources

The null hypothesis to test the relationship between the year 2000 project resources and estimated costs as a percent of annual IS budget was:

> **H4: There is no relationship between resources and estimated costs of year 2000 compliance projects as a percent of annual IS budget.**

As shown in the model, there are six sub-dimensions within the resources dimension: human resources, hardware, expertise, project management, management support, and tools. In the factor analysis done initially to validate the questionnaire items from the survey, the group of items concerning the adequacy of the various resources grouped logically into a single factor and emerged as a separate sub-dimension rather than each item aligning with the variables measuring the characteristics of the resource itself. Thus adequacy of project resources may be an influence separate from the resource itself. Although this finding varies somewhat from the model, the discussion of resources will examine the adequacy of resources as a seventh resource sub-dimensions, and it will be discussed first. Tables 4-12 through 4-14 present the correlations for resources and estimated percent cost.

Adequate Project Resources

Of the six questionnaire items measuring the adequacy of project resources, the analysis indicated significant relationships for five of them in at least one of the groups. The strongest evidence to support this relationship comes from projects in the early-planning stages, which indicated negative relationships for all five. The relationships for adequate authority (r = -.3349, $p \leq .01$, n = 55), human resources (r = -.3464, $p \leq .01$, n = 55), and time (r = -.3861, $p \leq .00$, n = 55) were of moderate magnitude, and the magnitude of the relationships indicated for adequate money ($r = -.2816$, $p \leq .04$, $n = 55$) and management support ($r = -.2769$, $p \leq .04$, $n = 55$) were only slightly below the moderate level. It is interesting that no relationships were indicated for projects in the later-planning stages.

The findings from the analysis of all respondents indicated three relationships for the adequacy of resources: but the magnitude for all three, human resource ($r = -.1849$, $p \leq .04$, $n = 126$), authority ($r = -.2032$, $p \leq .02$, $n = 126$), and time ($r = -.1856$, $p \leq .04$, $n = 126$), were low. A significant relationship for adequate time was indicated in the analysis of larger IS organizations, and two relationships were indicated for adequacy in smaller IS organizations -- authority ($r = -.4690$, $p < .00$, $n = 38$) and money ($r = -.3226$, $p < .04$, $n = 38$). The correlations found for the questionnaire items concerning the adequacy of resources were all negative, indicating, as would be expected, that having adequate resources may mean lower estimated costs since additional skills and technology costs would not be necessary.

External Human Resources

External resource needs appear to relate to consistently higher estimated costs. Table 4-12 shows the findings for the questionnaire items validated to measure the human resources sub-dimension. All the variables concerning human resources in the survey concern external human resources, however. In the analysis of all respondents, two of the items -- relying on outsourcing and contractors ($r = .2979$, $p \leq .00$, $n = 119$) and relying on consultants for external help ($r = .3197$, $p \leq .00$, $n = 114$) -- indicated statistically significant positive correlations of moderate magnitude with estimated percent cost. Organizations that use external human resources expect to have higher estimated percent cost perhaps because of increased costs due to the scarcity of IS professionals as the deadline approaches, or simply because external hired help costs more. The correlations for both these items were also statistically significant in the analysis for projects in both the early-planning and the later-planning stages (see Table 4-14). The findings from larger IS organizations supported the relationship for relying on outsourcing and contractors but not the relationship for consultants. The findings from smaller IS organizations were just the opposite; they supported the relationship for consultants but not the relationships for outsourcing and contractors. There was a high degree of consensus from all groups in the direction and magnitude of these relationships. They were all moderate or slightly below in magnitude and positive in direction.

<u>Table 4-12.</u> Correlation Indicated Between Resources And Estimated Costs of Year 2000 Compliance Projects as a Percent of Annual IS Budget for All Respondents and for Larger IS Organizations.

	All Respondents			Larger IS Organizations		
Adequate Project Resources:	*r*	*p*≤	*n*	*r*	*p*≤	*n*
As year 2000 project manager, I have completely adequate:						
Human resources.	**-.1849**	**.04**	**126**	-.0421	.76	56
Hardware capability.	.0113	.90	124	-.1351	.32	56
Management support.	-.0903	.31	126	-.1853	.17	56
Authority.	**-.2032**	**.02**	**126**	-.0977	.47	56
Money.	-.0774	.40	124	-.1357	.32	55
Time.	**-.1856**	**.04**	**126**	**-.2977**	**.03**	**56**
Human Resources:						
This organization will rely on ______________for external help with year 2000 date problem solutions:						
Outsourcing and contractors.	**.2979**	**.00**	**119**	**.3206**	**.02**	**51**
Offshore programmers.	-.0619	.54	101	-.1906	.22	44

Consultants.	**.3197**	**.00**	**114**	.1924	.18	50
Hardware:						
Hardware capacity is very adequate for compliance testing.	-.0369	.69	120	-.1104	.43	53
This organization has adequate test facilities:						
For mainframe applications and products.	.1299	.20	100	-.1169	.42	50
For midrange applications and products.	-.0861	.37	110	-.1186	.41	50
For microcomputer applications and products.	-.0102	.91	121	-.191	.17	52
Expertise:						
The people assigned are extremely well experienced at software maintenance.	**-.2289**	**.01**	**123**	-.1206	.39	54
The expertise of our year 2000 project team is totally adequate in the following areas:				.		
Analysis.	-.0348	.70	125	.0392	.78	54
Logical design.	-.0274	.77	121	.0252	.86	51
Standard setting.	-.0503	.58	124	-.0843	.55	53
Coding/programming.	.0761	.40	124	.0640	65	53
Data conversion.	.0163	.86	123	-.1150	.42	53
Data administration/database management.	-.0818	.37	121	-.0959	.51	51
Testing.	-.0450	.62	125	-.0518	.71	54
Software change management.	-.1154	.20	124	-.0606	.67	53
Project management.	-.0720	.43	125	.1282	.36	54
Software process methodology.	-.0470	.61	122	-.2014	.14	54
Interfacing or linking applications together.	-.0605	.50	124	-.1886	.17	54
Software quality assurance.	-.0943	.30	124	-.1516	.27	54
Setting priorities and planning.	-.0093	.92	125	.0644	.64	54
Contingency planning.	-.0187	.84	125	-.1328	.34	54
Risk management.	-.0854	.35	122	-.0660	.64	52
Project Management:						
This organization has centralized control of all year 2000 date efforts	-.0182	.84	126	-.1769	.20	55
This organization will have a centralized group to:						
Certify all applications.	.0849	.39	106	**.3135**	**.04**	**43**
Certify all purchased applications.	.0778	.42	109	.0996	.53	43
Certify all utility software products.	.1046	.28	109	**.3396**	**.03**	**43**
Certify all replacement applications.	.1000	.31	106	**.2656**	**.09**	**43**
Management Support:						
Top IS management ______________________the year 2000 date						

problem.						
Strongly supports and is committed to solving	-.0500	.58	126	**-.2930**	**.03**	**54**
Really understands the scope (how big it is) of	.0427	.64	125	-.1014	.47	54
Really understands the potential impact (how serious it is)	.0015	.99	126	-.1714	.22	54
Top organizational management ______________________the year 2000 date problem.						
Strongly supports and is committed to solving	.0747	.41	126	.0278	.84	54
Really understands the scope (how big it is)	-.0873	.33	126	.1223	.38	54
Really understands the potential impact (how serious it is)	-.1033	.25	126	.0755	.58	54
Tools:						
This organization will rely on vendor's tools for external help with year 2000 problem solutions.	**.1863**	**.05**	**114**	.1307	.36	52
Computer-based tools will play a significant role in:						
Determining the scope of the problem and inventorying applications.	.1258	.18	114	-.754	.60	52
Conducting impact assessment.	.0760	.42	114	-.1203	.40	52
Storing and managing inventory and impact data.	.0422	.66	113	-.0881	.54	52
Planning, scheduling, budgeting and prioritizing.	.0974	.30	117	.0337	.81	54
Converting and/or replacing code.	-.1186	.21	113	-.1555	.27	52
Testing the solution.	-.0584	.54	115	**-.2765**	**.04**	**54**
Change management.	.0038	.97	119	-.2031	.14	54
Estimating cost.	.0399	.68	115	-.0815	.57	52
Modifying data.	-.0449	.64	116	**-.2761**	**.04**	**53**

Hardware Resources

None of the four questionnaire items validated to measure hardware resources indicated a statistically significant correlation with estimated percent cost in any of the five analysis groups.

Table 4-13. Statistically Significant Correlation Indicated Between Resources and Estimated Costs for Year 2000 Compliance Projects as a Percent of Annual IS Budget for Smaller IS Organizations.			
Adequacy of Resources:	*r*	*p*≤	*n*
As year 2000 project manager, I have completely adequate:			
Authority.	**-.4690**	**.00**	**41**
Money.	**-.3226**	**.04**	**41**
Human Resources:			
His organization will rely on consultants for external help with the year 2000 date problem.	**.3420**	**.04**	**38**
Expertise:			
The people assigned are extremely well experienced at software maintenance.	**-.3571**	**.02**	**41**
The expertise of our year 2000 project team is totally adequate in the following areas:			
Data conversion.	**-.3423**	**.02**	**41**
Interfacing and linking applications.	**-.3098**	**.05**	**41**
Contingency planning.	**-.3526**	**.02**	**41**
Project Management:			
This organization has centralized control of all year 2000 date efforts.	**-.4263**	**.01**	**40**

Expertise

Although no relationships were indicated for expertise in the analysis of all respondents or for larger IS organizations, four of the questionnaire items concerning expertise indicated a statistically significant negative correlation of moderate magnitude with estimated percent cost in the analysis of smaller IS organizations. The findings indicated that expertise relates to lower estimated costs as indicated by the negative correlation between the questionnaire item that the people assigned are extremely well experienced at software maintenance (r = -.3571, $p \leq$ .02, n = 41). The other three relationships indicated for smaller IS organizations were for "totally adequate" expertise in data conversion (r = -.3423, $p \leq$ .02, n = 41), in interfacing and linking applications (r

= -.3098, $p \leq .05$, $n = 41$), and in contingency planning ($r = -.3526$, $p \leq .02$, $n = 41$). All these relationships were negative and moderate in magnitude, indicating that high levels of available expertise may mean lower percent cost.

The analysis of projects in the early-planning stages supported these relationships for expertise with a similar negative correlation indicated between the questionnaire item that the people assigned are extremely well experienced at software maintenance ($r = -.3625$, $p \leq .00$, $n = 50$) and estimated percent cost. Early-planning stage projects also indicated significant relationships for three other “totally adequate” expertise areas, (1) software change management, (2) software process methodology, and (3) software quality assurance. The relationships for these three were negative and just below the .3 magnitude threshold. No relationships were indicated in early-planning stage projects for data conversion, for interfacing and linking applications, or for contingency planning. This may simply mean that early-planning stage project managers have not yet begun to address these tasks. There was consistency overall that expertise has a negative relationship with estimated percent cost.

Project Management Resources

Table 4-12 shows that there were five questionnaire items measuring project management resources and that the analysis of all respondents did not find any statistically significant correlations for project management variables. The analysis of the questionnaire items concerning centralized control of Y2K projects provided weak evidence to support a relationship for project management resources with three relationships indicated for larger IS organizations and one for smaller IS organizations.

There was not consensus on the direction of the relationship, however. The finding from smaller IS organizations was that centralized control of projects ($r = -.3571$, $p \leq .02$, $n = 41$) relates to lower estimated costs, but the findings from larger IS organization indicated that organizations that have a centralized group to certify all applications ($r = .3135$, $p \leq .04$ $n = 43$), utility software products ($r = .3396$, $p \leq .03$ $n = 43$), and replacements applications ($r = .2656$, $p \leq .09$ $n = 43$) have higher estimated costs. A possible explanation for the difference in the direction of the relationships concerning centralized groups for certification may be that the centralized project team in larger IS organizations is less familiar with the systems. Thus the overhead from having to become familiar with the information systems of the organization may eliminate any economies of scale obtained from centralization of Y2K projects. Higher costs may also be a reflection of the additional overhead of centralized project coordination and integration in large organizations.

Management Support

Table 4-12 shows that there were six questionnaire items concerning management support, three concerning top IS management and three concerning top organizational managements. No relationships were indicated in the analysis of all respondents, and only one relationship, that top IS management strongly supports and is committed to solving the year 2000 date problem ($r = -.2930$, $p \leq = .03$, $n = 54$), was indicated in projects in larger IS organizations. The strongest support for a relationships between management support and estimated costs came from the analysis of projects in the early-planning stages, which indicated negative relationships for these three questionnaire items -- that top IS management strongly supports and is committed to solving the year 2000 date problem (r = -.3202, $p \leq$ = .02, n = 55), that top organizational management really understands the scope (r = -.3835, $p \leq$ = .00, n = 55,) and that top organizational management really understands the potential impact (r = -.3131, $p \leq$ = .02, n = 55). The direction of all the relationships indicated was negative and indicated that Y2K managers who have strong management support have lower estimated costs. The findings indicated that the support of upper management is a critical success factor for Y2K projects as well as for other IS projects.

Tools

Table 4-12 shows that there were ten questionnaire items validated to measure the relationships between use of tools and estimated costs. The findings indicated possible relationships for only three of the items, one in the analysis of all respondents and two in larger IS projects. The analysis of all respondents indicated a positive correlation, but with low magnitude, for the questionnaire item concerning the organization's reliance on vendor's tools for external help with the year 2000 problem solutions (r = .1863, $p \leq$ = .05, n = 114). Relationships were indicated in the analysis of larger IS organizations for the questionnaire items that computer-based tools will play a significant role in (1) testing the solution (r = -.2765, $p \leq$ = .04, n = 54) and (2) modifying data (r = -.2761, $p \leq$ = .04, n = 53). It is reasonable that the level of tool use in larger IS organizations relates to cost savings from use of tools for testing and modifying data.

Summary of Hypothesis 4 Findings

There was sufficient evidence to reject the null hypothesis, that there were no relationships between estimated costs and resources, particularly on the basis of the strength of the relationships indicated for the adequacy of resources and for external human resources. Based on the strength rating criteria, the evidence for support of a relationship indicated between the adequacy of resources and estimated costs was moderate for smaller IS organizations, moderately strong for all respondents, and strong for projects in the early planning stages. The evidence for support of a relationship between use of external human resources and estimated costs was strong for all respondents and for both project stage groups and was moderate for both larger and smaller IS organizations. There was also moderately strong support for a relationship between project management resources and estimated costs from larger organizations. The findings indicated weak support for a relationship between expertise and estimated costs in smaller IS organizations and in projects in the early-planning stages. No evidence above the level of random occurrence was indicated for support of relationships for hardware or tools and estimated costs, however.

Hypothesis 4A: Resources by Project Stage

The null hypothesis for testing that the relationships between the project resources and estimated percent cost varies by project stage was:

> **H4A: There is no relationship between resources and estimated costs of year 2000 projects as a percent of annual IS budget when moderated by project stage.**

There is ample evidence to reject the null hypothesis that there is no difference in the relationship between estimated costs and resources by project stage. As Table 4-14 indicated, there were 14 independent variables that correlated with estimated percent cost for projects in the early-planning stages, and only four variables that correlated with it in the later-planning stages. Of the relationships indicated for projects in the early-planning stages, eight were above the .3 strength threshold and the other six were very close to it.

Table 4-14. Statistically Significant Correlation Indicated Between Resources and Estimated Costs for Year 20000 Compliance Projects as a Percent of Annual IS Budget When Moderated by Project Planning Stage.

	Projects in Early-Planning Stages			Projects in Later-Planning Stages		
Adequate Resources:	*r*	*p*≤	*n*	*r*	*p*≤	*n*
As year 2000 project manager, I have completely adequate:						
Human resources.	**-.3464**	**.01**	**55**	-.1094	.38	67
Authority.	**-.3349**	**.01**	**55**	-.1110	.37	67
Management support.	**-.2769**	**.04**	**55**	.0440	.72	67
Money.	**-.2816**	**.04**	**55**	.0805	.52	65
Time.	**-.3861**	**.00**	**55**	-.1345	.28	67
Human Resources:						
This organization will rely on ______________for external help with year 2000 date problem solutions:						
Outsourcing and contractors	**.3145**	**.02**	**52**	**.2815**	**.02**	**64**
Consultants	**.2748**	**.05**	**50**	**.3563**	**.01**	**61**
Expertise:						
The people assigned are extremely well experienced at software maintenance.	**-.3625**	**.00**	**54**	**-.2116**	**.09**	**66**
The expertise of our year 2000 project team is totally adequate in the following areas:						
Software change management.	**-.2688**	**.05**	**54**	.0027	99	66
Software process methodology.	**-.2982**	**.03**	**51**	.1836	.14	67
Software quality assurance.	**-.2940**	**.03**	**53**	.0114	.93	67
Management Support:						
Top IS management strongly supports and is committed to solving the year 2000 date problem.	**-.3131**	**.02**	**55**	.0829	.51	68
Top organizational management strongly supports and is committed to solving the year 2000 date problem.	-.1698	.22	55	**.2237**	**.07**	**68**
Top organizational management really understands the scope.	**-.3202**	**.02**	**55**	.0204	.87	67
Top organizational management really understands the potential impact.	**-.3835**	**.00**	**55**	.0954	.44	67

There was consensus between the groups on the two variables concerning use of external human resources, and the items for relying on (1) consultants and on (2) outsourcing and contractors for external help both have a positive correlation of approximately .3. These findings may mean that initially project managers anticipated that adequate resources, management support, and expertise would influence estimated percent cost but that the cost of labor was the primary influence as projects progressed into the later-planning stages. These findings are supported somewhat by the scarcity and dramatic increase in the cost of human resources available for year 2000 projects and IT projects in general as the deadline approached. When additional resources were required, they came at a premium.

With the exception of these two items concerning external resources, the relationships were very different. Projects in the early-planning stages indicated significant relationships for all the adequate resource items except for hardware, and there were no relationships indicated for projects in the later-planning stages. The difference in the number of relationships alone was sufficient evidence to reject the null hypothesis that there was no difference in the relationships between resources and estimated percent cost when moderated by for project stage.

Hypothesis 5: Stage of Project Completion

The null hypothesis to test the relationship between the year 2000 project stage and estimated costs as a percent of annual IS budget was:

H5: There is no relationship between estimated costs of year 2000 compliance projects and stage of project completion.

There is minimal evidence to reject the null hypothesis using the established criteria because of a weak rating (27%) from smaller IS organizations. The evidence from all respondents was very weak and no more than random occurrence for larger IS organizations. Table 4-15 shows the fifteen validated measures for stage of project completion and the corresponding correlation of each with estimated percent cost for all respondents and for larger IS organizations. Table 4-16 shows the findings for smaller IS organizations and negative correlations of moderate magnitude for four questionnaire items, that the organization has (1) already solved the problem at the code and data level ($r = -.3970$, $p \leq .02$, $n = 38$), (2) already tested its compliance solutions(s) ($r = -.2663$, $p < .10$, $n = 39$), (3) implemented and made operational its solution(s) ($r = -.3233$, $p \leq .05$, $n = 37$), and (4) already solved the problem and is year 2000 date compliant ($r = -.3388$, $p < .03$, $n = 40$). The findings from the analysis of all respondents provided additional support for two of these negative relationships, progress in solving the problem at the code and data level and that the organization has already solved the problem and is compliant, but the magnitude of the relationships was lower than the magnitude of the relationship found in smaller IS organizations. There are several possible explanations for these relationships: (1) organizations that started and finished early have fewer affected systems or smaller compliance projects, (2) human resources costs increased significantly as the deadline approached, or (3) organizations that finish early, managed their projects more effectively and efficiently.

The only relationship indicated for larger IS organizations was a significant and positive correlation between estimated percent cost and the organization's progress in determining the scope of the problem, inventorying applications, conducting an impact assessment. The positive direction of this relationship may indicate that, although solving early appears to pay off, estimated costs continue to increase until detailed plans and budgets are in place, at least for larger Y2K projects.

Table 4-15. Correlation Indicated Between Project Stage and Estimated Costs for Year 20000 Compliance Projects as a Percent Of Annual IS Budget for All Respondents and Larger IS Organizations.

	All Respondents			Larger IS Organizations		
	r	*p*≤	*n*	*r*	*p*≤	*n*
This organization has:						
Is well aware of the year 2000 problem.	.0467	.60	128	-.0890	.51	56
Studied the problem, inventoried its applications, and conducted an impact analysis.	.0544	.60	128	.0494	.72	56
Has completed an impact study to determine the exact nature of our year 2000 problem on all hardware, software, and data assets.	.0289	.75	123	.0462	.74	53
Has detailed plans, schedules, and budgets for solving the problem.	.0847	.35	128	.0336	.81	56
Has completed an inventory of all hardware, software, and data assets.	.0454	.61	127	-.0232	.87	56
Has conducted pilots to validate its year 2000 budget estimates.	.0400	.67	119	-.1141	.41	54
Already solved the problem at the code and data level.	**-.2004**	**.03**	**121**	-.1921	.16	55
Already tested its compliance solutions(s).	-.1077	.24	123	-.0675	.62	56
Implemented and made operational its solutions(s).	-.0806	.38	120	-.1123	.41	55
Already solved the problem and is year 2000 date compliant.	**-.2196**	**.02**	**122**	-.1840	.19	53
Estimated percent complete for:						
Determining scope of problem, inventorying applications, conducting an impact assessment.	.1168	.21	116	**.3254**	**.02**	**50**
Planning, scheduling, budgeting, and prioritizing.	.0145	.88	112	.1139	.45	47
Converting and/or replacing code, modifying data, and replacing hardware.	-.0997	.30	110	-.0225	.88	46
Testing the solution.	-.1529	.11	108	-.1469	.33	46
Making the solution operational.	-.0766	.44	106	-.1696	.27	44

<u>Table 4-16.</u> Statistically Significant Correlation Indicated Between Project Stage and Estimated Costs for Year 20000 Compliance Projects as a Percent of Annual IS Budget for Smaller IS Organizations.			
This organization has:	*r*	*p*≤	*n*
Already solved the year 2000 problem at the code and data level.	**-.3970**	**.01**	**38**
Already tested its compliance solution(s).	**-.2663**	**.10**	**39**
Implemented and made operational its solution(s).	**-.3233**	**.05**	**37**
Already solved the problem and is year 2000 date compliant.	**-.3388**	**.03**	**40**

Summary

The findings provided sufficient evidence to justify rejecting four of the five hypotheses in at least one of the five groups analyzed. Using the establish criteria for rating the evidence found, there was sufficient evidence to justify possible relationships for organization, problem, resources, and stage with estimated costs but with minimal evidence for project stage. The findings indicated sufficient evidence to reject two of the alternate hypotheses, those for organization and for resources, that the cost influence relationships do not differ by project stage, as well.

CHAPTER 5

CONCLUSIONS

Introduction

The purpose of this research was to examine the relationships shown in the Year 2000 Enterprise Cost Model (Figure 2 in Chapter 1). Five research questions and corresponding hypotheses were developed from the cost influence relationships described in the model:

1. Do organizational characteristics -- size, industry, and IS practices -- influence estimated costs of Y2K projects?

2. Do the characteristics of the Y2K problems in an organization -- awareness, impact, complexity, size, and scope -- influence estimated costs of Y2K projects?

3. Do the characteristics of the Y2K solutions chosen by an organization influence estimated costs of Y2K projects?

4. Do available resources -- human, expertise, tools, project management, hardware, and outsourcing -- influence estimated costs of Y2K projects?

5. Are estimated costs related to stage of completion of Y2K projects?

An alternate hypothesis was developed for each of the first four research questions to examine the influence of project stage on these relationships.

In this chapter, the findings and implications from the tests of the five hypotheses that were derived from the research questions above are presented first. The discussion of the first four hypotheses also includes the findings and implications from the test of the alternate hypotheses concerning the influence of project stage on these relationships.

After the discussion of the findings and implications for the five hypotheses, a summary of the conclusions drawn is presented, followed by a discussion of possible refinements to the Year 2000 Enterprise Cost Model. The chapter concludes with a discussion of the limitations of this research and suggested areas for future research.

Findings and Implications

The tests of the five hypotheses consisted of individually testing each of the independent variables validated to measure the dimensions and sub-dimensions of the model for a statistically significant relationship (i.e., correlation) with the dependent variable, estimated Y2K project costs as a percent of annual IS budget (percent cost). See Table 4-1 in Chapter 4 for a summary of the terminology and definitions used throughout this document.

This research included analysis of the data as a whole for all respondents and also analyses of the respondents grouped by IS organization size and by the stage of completion of their Y2K projects. Two groups were selected for IS organization size, the lower forty percent of respondents, those having revenue of $10 million or less, and the upper forty percent, organizations having IS budgets of $20 million or more. Respondents were also grouped into projects in the early-planning stage and projects in the later-planning stage based on responses for level of agreement that “this organization has detailed plans, schedules, and budgets for solving the year 2000 date problem.” An interesting finding itself was that not enough projects had progressed beyond the planning stages to use variables measuring progress in later stages for this grouping.

Table 5-1. Summary of the Independent Variables Correlated with Estimated Percent Cost by Sub-Dimension for All Respondents.						
		Number of Correlations				Evidence
	Variables Tested	p ≤.01	p ≤.05	p ≤.10	Total	Strength Rating
Hypothesis 1 – Organization						
Size	9	1	0	2	3	Weak
IS Practices	30	1		2	3	Random
Total	39	2		4	6	
Hypothesis 2 – Problem						
Awareness	8		1		1	Very weak
Impact	5	2	1		3	Strong
Complexity & Scope	7	1	0	2	3	Moderately Strong
Total	20	3	2	2	7	
Hypothesis 3 – Solution						
Solution	20	1	3		4	Very Weak
Hypothesis 4 – Resources						
Adequate Resources	6		3		3	Moderately Strong
External human	3	2			2	Strong
Hardware	4					
Expertise	16	1			1	Random
Project Management	5					
Management Support	6					
Tools	10		1		1	Random
Total	50	3	4		7	
Hypothesis 5 – Stage						
Stage of Project Completion	15		2		2	Very Weak

Tables 5-1 through 5-3 in this chapter summarize the evidence found in this research concerning the five hypotheses examined and present the number of variables tested for each sub-dimension or dimension of the model, the number of statistically significant relationships indicated, and a ranking for the strength of the evidence

Table 5-2. Summary of the Independent Variables Correlated with Estimated Percent Cost by Sub-Dimension for Larger and Smaller IS Organizations.											
		Larger IS Organizations					Smaller IS Organizations				
		Number of Correlations					Number of Correlations				
	# Var.	*p*≤ .01	*p*≤ .05	*p*≤ .10	Total	Rating (*)	*p*≤ .01	*p*≤ .05	*p*≤ .10	Total	Rating (*)
Hypothesis 1 – Organization											
Size	9			1	1	VW	2			2	W
IS Practices	30	3	6	3	12	M	2	2		4	VW
Total	39	3	6	4	13		4	2		6	
Hypothesis 2 – Problem											
Awareness	8	1			1	VW		1		1	VW
Impact	5		1	2	3	S					
Complexity & Scope	7	0	0	2	2	W	1			1	VW
Total	20	1	1	4	6		1	1		2	
Hypothesis 3 – Solution											
Solution	20			1	1	R	1			1	R
Hypothesis 4 – Resources											
Adequate	6		1		1	VW	1	1		2	M
External human	3		1		1	M		1		1	M
Hardware	4										
Expertise	16							4		4	W
Project Management	5		2	1	3	S	1			1	VW
Management Support	6		1		1	VW					
Tools	10		2		2	VW					
Totals	50		7	1	8		2	6		8	
Hypothesis 5 – Stage											
Stage	15		1		1	R	1	2	1	4	W
* Rating for strength of the evidence found, R = random, VW = very weak, W = weak, M = moderate, MS = moderately strong, S = strong											

found supporting each relationship described in the Year 2000 Enterprise Cost Model as tested in this research. Table 5-1 summarizes the findings from the analysis of all respondents. Table 5-2 summarizes the findings by IS organization size, and Table 5-3 summarizes the findings for projects grouped by stage of project. See Tables 4-2 through 4-16 in Chapter 4 for the complete results of the individual tests of the independent variables.

Since the results included relationships having a confidence level of 90% or higher, random occurrence can explain as many as 10 percent of the significant correlations. Hence, the following scale was used initially to rank the strength of the evidence for the existence of a relationship between project cost and a particular a sub-dimension or dimension:

Random	1-10%
Very weak	11-20%
Weak	21-30%
Moderate	31-40%
Moderately strong	41-50%
Strong	51% or higher

The initial assessment was adjusted in some cases for the content of variables and for the magnitude of the relationships indicated. Responses to questionnaire items that broadly assessed a dimension or sub-dimension were weighted more heavily than items that addressed a very specific characteristic of a dimension. Relationships indicating a magnitude of .3 and above, as measured by the *r*-value of its correlation, were weighted more heavily than those below .3. These adjustments were assigned subjectively rather than algorithmically and are noted in the discussion. A subjective weighting like this, although prone to some degree of error, is acceptable in exploratory research.

As Tables 5-1 to 5-3 indicate, there was sufficient evidence to support the existence of relationships with project cost for organization, problem, resources, and project stage but not sufficient evidence to support a relationship for solution. Overall the strength of the evidence to support these relationships was weak to moderate. A discussion of the findings for each hypothesis follows.

Table 5-3. Summary of the Independent Variables Correlated with Estimated Percent Cost by Sub-Dimension for Projects in the Early-Planning and the Later-Planning Stages.

		Projects in Early-Planning Stages					Projects in Later-Planning Stages				
		Number of Correlations					Number of Correlations				
	# Var.	*p*≤ .01	*p*≤ .05	*p*≤ .10	Total	Rating (*)	*p*≤ .01	*p*≤ .05	*p*≤ .10	Total	Rating (*)
Hypothesis 1 – Organization											
Size	9						1			1	VW
IS Practices	30	6	3	1	10	M		1		1	R
Total	39	6	3	1	10		1	1		2	
Hypothesis 2 – Problem											
Awareness	8		1		1	VW					
Impact	5										
Complexity & Scope	7						1			1	VW
Total	20		1		1		1			1	
Hypothesis 3 – Solution											
Solution	20										
Hypothesis 4 – Resources											
Adequate	6	3	2		5	S					
External human	3		1	1	2	S	1	1		2	S
Hardware	4										
Expertise	16	1	3		4	W			1	1	R
Project Management	5										
Management Support	6	1	2		3	MS			1	1	VW
Tools	10										
Total	50	5	9	1	14		1	1	2	4	

* Rating for strength of the evidence found, R = random, VW = very weak, W = weak, M = moderate, MS = moderately strong, S = strong

Hypothesis 1: Relationship of Organization to Estimated Costs

Hypothesis 1 concerned the relationship between organizational characteristics and estimated costs of Y2K projects. The analysis first involved comparison of mean estimated percent cost by industry groups, but no evidence was found to support a difference by industry. The analysis for organization continued with correlations between estimated percent cost and the individual independent variables validated to measure two sub-dimensions of organizational characteristics -- size and IS practices. As Tables 5-1 through 5-3 present, the research provided weak evidence to support a relationship between estimated percent cost and size and moderate support for a relationship for IS practices in at least one of the analysis groups using the rating criteria defined earlier in this chapter. The detailed findings from the tests of the independent variables for organizational characteristics are presented in Tables 4-2 through 4-6 in Chapter 4.

The strongest evidence of support for a relationship for size comes from all respondents, with relationships indicated for three of the nine size measures (33%). The analysis indicated correlations with a magnitude of greater than .3 for three different size variables -- division revenue, the number of people in the IS organization, and lines of code in the organization -- and correlations of lesser magnitude for three other size variables -- the number of software application in the organization, the number of people in the parent organization, and IS operating budget -- in at least one of the analysis groups. The relationships for size measures differ considerably among the five analysis groups, however.

Larger IS organizations provided the strongest evidence to support a relationship for IS practices with relationships indicated for 12 of the 30 measures (40%). Early-stage projects indicated 10 relationships for IS practices, and the later stage group indicated only one. There is consistency that the relationships indicated for IS practices in all analysis groups were negative The relationships indicated for IS practices fall into 4 categories: (1) definition and use software process methodologies within the organization, (2) cost estimating methods and metrics, (3) quality improvement measures, and (4) project management practices.

There were considerable differences in the findings for the size groups and for the project stage groups, but there was a high degree of similarity in number of items indicating significant relationships for IS practices in larger IS organizations and in projects in the early-planning stages. The differences in the relationships indicated for projects in the early-planning and the later-planning stages was perhaps one of the more interesting findings of this study. The difference in the number of relationships indicated between the size groups may possibly be explained by that fact that smaller organizations should have less complex systems and smaller staff and, thus, would probably have implemented fewer formal IS practices. Another possible explanation is that Y2K projects are not typical software development projects that benefit from improved IS practices, although project managers initially think so. An explanation for the lack of findings for the difference by project stage is not as easy to explain since IS practices should be important throughout the life of a software project.

<u>Hypothesis 2: Relationship of Problem to Estimated Costs</u>

Hypothesis 2 concerned the relationship between the characteristics of the Y2K problem and estimated costs of compliance projects. The analysis included correlation of the independent variables validated to measure three sub-dimensions of the problem -- awareness, impact, and scope/complexity -- with the dependent variable, estimated percent cost. As Tables 5-1 through 5-3 present, this study provided very weak evidence to support a relationship for awareness, strong support for a relationship for impact, and moderately strong support for a relationship for complexity and scope using the rating criteria defined earlier in this chapter. The basis of the support is the statistical significant relationships indicated for three of the five measures for impact (60%) for all respondents and for larger IS organizations and for three of the seven measures of complexity and scope (43%) for all respondents. Project stage does not appear to moderate the relationship between estimated percent cost and any of the problem sub-dimensions. The detailed findings from the tests of the independent variables for organizational characteristics are presented in Tables 4-7 through 4-9 in Chapter 4.

In spite of an emphasis in the literature (Kappelman, 1996; Kappelman & Cappel, 1996; Ulrich & Hayes, 1997) on the importance of awareness, the evidence supporting a relationship between awareness and estimated costs was very weak. The positive direction indicated that increased awareness means increased estimated costs.

There were a high number of relationships indicated for variables measuring impact, but the magnitude of most of the correlations was low. No relationships were indicated in any of the groups for an external impact on the organization’s competitive advantage or in its ability to serve customers or citizens. The lack of findings for an external impact may be associated with the negative correlations found for variables measuring the confidence of IS and top managers that projects will be completed before the deadline. On the other hand, managers may simply be focusing inwardly and have not progressed to the point of assessing external risks for the organization.

There was moderately strong evidence to support a relationship between the complexity and scope of the problem and estimated costs, particularly in larger IS organizations. Hardware and system software may contribute to the complexity and scope of the problem and increase estimated costs. The significant correlations for both were positive and moderate in magnitude, indicating, as one might expect, that having to upgrade and replace hardware or system software will add to the cost of compliance projects.

Project stage did not appear to influence the relationships between the Y2K problem and estimated costs. The differences for problem seemed to be related more to IS organization size than to the stage of completion of projects. It is reasonable that the problem would not change significantly as projects progress into the later stages of planning unless the organization had overlooked significant portions of the problem initially.

Hypothesis 3: Relationship of Solution to Estimated Costs

Hypothesis 3 concerned the relationship between the characteristics of Y2K solutions and estimated costs for compliance projects. As Tables 5-1 through 5-3 present, this research provided very weak evidence to support a relationship of cost with solution. The evidence found can be explained as a random occurrence in all of the analysis groups except for projects in the early-planning stages, in which the evidence was rated very weak with relationships indicated for four of the 20 solution measures (20%). This research did not indicated that either size or project stage particularly affected the relationship of solution and cost. The Y2K problem may be the primary influence for solution and may determine the subsequent influence of solution on estimated costs. The detail findings from the tests of the independent variables for organizational characteristics are presented in Tables 4-2 through 4-6 in Chapter 4.

Solving early may lower costs for Y2K projects. Two of the significant relationships indicated for all respondents concerned solving early -- that the organization has already solved the problem at the code and data level and already solved the problem and is year 200 compliant. A possible explanation for this finding is the increased scarcity and thus costs of resources as the deadline approached.

The negative relationships indicated for the confidence of the year 2000 project manager to be compliant with time or money to spare are interesting. In the analysis of all respondents and in larger IS organizations, Y2K project managers who are confident that their projects will be completed on time indicated lower estimated percent cost. In smaller IS organizations, Y2K project managers who are confident that their projects will be completed within the money budgeted indicated lower estimated percent cost. Does this mean that these managers have lower estimated cost because they are managing their projects more efficiently and effectively or only that they have not yet discovered all the costs of their projects and thus are overly confident?

Hypothesis 4: Relationship of Resources to Estimated Costs

Hypothesis 4 concerned the relationship between the characteristics of the resources required for Y2K projects and estimated costs of compliance projects. The analysis included correlations of the independent variables validated to measure seven sub-dimensions of resources—availability of resources, use of external human resources, hardware, expertise, project management, management support, and tools -- with the dependent variable, estimated percent cost. As Tables 5-1 through 5-3 present, there was some evidence to support possible relationships for six of the seven sub-dimensions of resources with support provided primarily from smaller IS organizations and projects in the early-planning stages. The significant relationships indicated for resources, particularly for adequate resources, expertise, and management support differ by project stage as well. The detailed findings from the tests of the independent variables for organizational characteristics are presented in Tables 4-2 through 4-6 in Chapter 4.

This analysis indicated moderately strong support from all respondents for a significant relationship for adequate resources with three of the six (50%) measures and strong support from projects in the early-planning stages with significant relationships indicated for five of the six (83%) measures. The only measure for which a relationship was not indicated in at least one of the analysis groups was for adequate hardware resources. Likewise no relationships were indicated as significant for the hardware sub-dimension of resources. In the analysis for problem, however, relationships were indicated for variables measuring hardware as it contributes to complexity and scope. Thus hardware requirements may contribute to the problem and increase costs; but conversely, if hardware resources are not adequate, they do influence costs.

There was a high degree of consistency in all the analysis groups that use of consultants, outsourcing, and contractors relates to increased estimated costs. The correlations for the relationships indicated were positive and the rating of evidence was strong with significant relationships indicated for two of the three (67%) measures for all respondents, and for both projects in the early- and the later-planning stages. These relationships were not surprising; given the scarcity and increased cost of IS professionals as the deadline approached.

Weak support for a relationship between estimated costs and expertise was provided by projects in the early-planning stages and smaller IS organizations, with relationships indicated for 4 of the sixteen measures (25%). The other groups indicated no relationships or had a random occurrence rating. The differences in the finding between the size groups probably relate more to the level of expertise required for the organization than to the level of expertise of the project team. Smaller IS organizations probably do not require the same level of expertise as larger IS organizations because of the differences in the complexity and scope of their systems. The difference by project stage may mean that the level of expertise that project managers expect to require initially may not be adequate as projects progress toward completion; or possibly, only that expertise is more of a focus for project managers in the early stages when they are acquiring and assigning resources to Y2K projects.

There was strong evidence to support a significant relationship between estimated percent cost and project management in larger IS organizations with relationships indicated for 3 of the 5 measures (60%). All of the project management measures concern centralization of Y2K efforts, however; and the relationships indicated were positive, meaning that centralization relates to higher rather than lower costs. The one relationship indicated in smaller IS organization was negative. Smaller IS organizations probably have smaller, less complex Y2K projects that possibly can be more easily and economically managed centrally. The larger, more complex Y2K projects in larger IS organizations may be more effectively managed centrally, but there is a cost of doing this. The risk reduction obtained from central project management in larger organizations is likely worth the added costs.

The evidence found to support a significant relationship between estimated cost and management support was moderately strong with relationships indicated for 3 of the 6 measures (50%) in projects in the early-planning stages. One significant relationship was indicated in projects in the later-planning stages, and one in larger IS organizations giving a very weak rating, but the other groups indicated no relationships. These findings support the idea that top management support is a critical success factor for the success of an IS project (Teo and Ang, 1999). A possible explanation for the negative relationships is that project managers who have the support of top management no longer have to inflate estimated impacts and costs in order to sell management on the acceptance and funding of these projects.

The only evidence above the random occurrence rating for tools was very weak support from larger IS organizations with relationships indicated for two out of the ten (20%) measures. The negative relationships indicated for measures concerning a significant role for the use of computer-based tools for change management and for modifying data may indicated that a history of reliance on tools to manage technological change may decrease problem scope and thus costs, although use of tools in projects may also contribute to cost reduction especially for data conversion.

There was evidence to support differences for the relationships for resources by project stage. Fifteen relationships were indicated for projects in the early-planning stages and only four in projects in the later-planning stages. There was consistency in the direction of the relationships indicated between groups but, with one exception, the relationships for projects in the early-planning stages were larger in magnitude as well as higher in number. A possible explanation for these differences is that project managers are focusing on acquiring resources during the early-planning stages so are more aware of resource needs and characteristics. In the later-planning stages, project resources may have been acquired and thus no longer be a focus for project managers or may simply have costs less than anticipated.

Hypothesis 5: Relationship of Project Stage to Estimated Costs

Hypothesis 5 concerned the relationship between stage of completion and estimated costs for Y2K compliance projects. As shown in Tables 5-1 through 5-3, the analysis found weak evidence in smaller IS organizations to support a relationship for stage with significant relationships indicated for 4 of the 15 (27%) measure and very weak evidence in all respondents with 2 (13%) relationships indicated. Tables 4-15 and 4-16 in Chapter 4 present the results of the tests for the individual variables measuring stage.

It appears that solving early may contribute to lower costs. Organizations that have solved their problems appear to have lower estimated percent cost, particularly smaller IS organizations. This finding may be misleading, however, since there was no evidence to support this relationship in larger IS organizations. Organizations that have already solved their Y2K problems possibly handled their projects more efficiently or may simply have had smaller, less complex projects. These findings may also reflect the increased costs for resources as the deadline approached, however.

The only significant relationship indicated in larger IS organizations was a positive correlation between the estimated percent compete for determining scope, inventorying applications and conducting an impact assessment and estimated percent cost. Up-front work in early stages may mean higher costs or may simply mean that total project costs are identified more accurately and completely if done earlier.

Summary of Findings and Implications

Two major conclusions can be drawn from this research:

1. Y2K compliance projects are very complex and thus cost estimating is also.
2. The devil of cost estimating is in the details of knowing which of the many possible variables are the important ones for the enterprise because Y2K projects appear to have many individual differences, particularly related to size and to project stage.

Year 2000 projects, as with most software development projects, are very complex, and their complexity has probably been underestimated. The five components of the model appeared to represent the attributes of Y2K projects fairly well initially because the independent variables aligned with the dimensions of the model to a large degree. An attempt to sum the factor scores for the dimensions or even for the sub-dimensions, however, did not correlate with cost. This may mean that colinearity was at play or that there is some other kind of statistical noise in the data, but also may indicated that the attributes interact at a level below the dimension level or that the relationships are more complex than the model indicates.

Y2K projects (and other software development projects) differ individually by organization and by project; and thus the devil is in the details for understanding cost influences. The relationships indicated as significant were at the detailed individual item level rather than either the sub-dimension or the dimension level in most cases. Understanding costs may mean understanding project- and organization-specific influences. Support was found that the organization, problem, resources, and stage dimensions appear to influence estimated costs, but there were considerable differences in the relationships indicated for the sub-dimensions within a dimension.

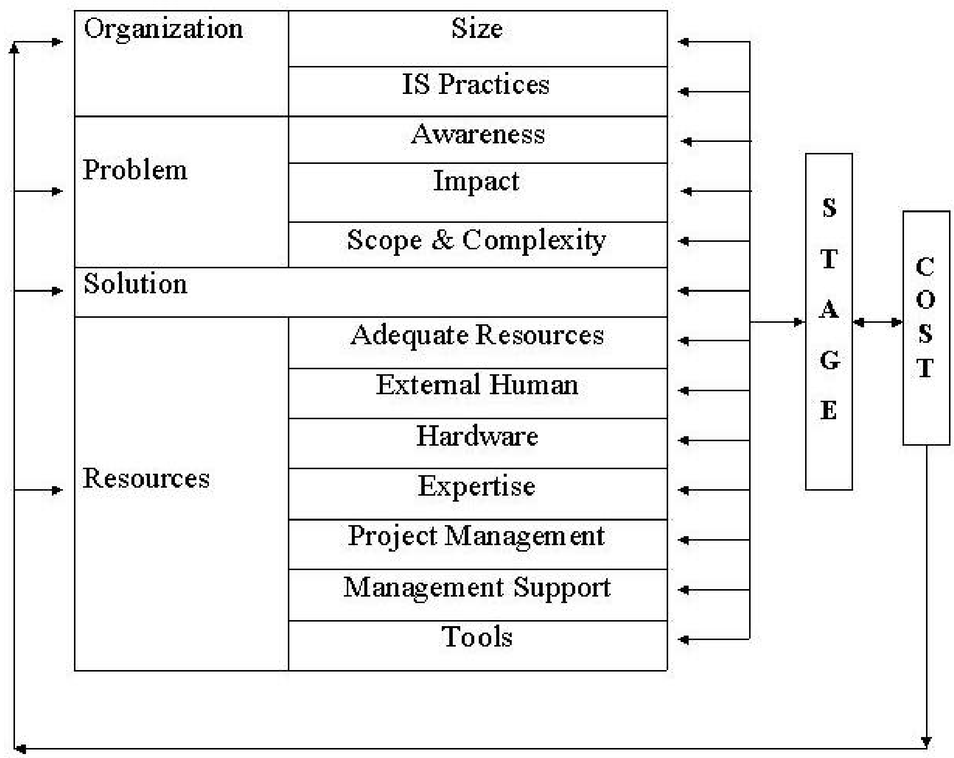
Higher-level models and tools for cost estimating allow calibration or adjustment for specific organization and project attributes, so the details may be the key to successful cost estimating. The results of the groups by size and by project stage did differ, and Y2K projects may not be as alike as initially thought. The magnitude of most correlations was low and ranged primarily from .2 to .4. Few of the correlations were larger than moderate in magnitude ($r \geq .3$), and there was a high degree of variation in the relationships indicated for the five groups analyzed. The low magnitude of the significant relationships and the variation in the findings among the groups may indicated that Y2K compliance projects were very diverse and in some ways unique for each organization, not an unreasonable condition given the uniqueness of organizations.

Cost estimating is far from static even for similar projects within a single organization. As an example, this study indicated that the relationships overall differed by organization size and that size may influence cost up to a point; but, once a certain size is reach, it may no longer be a significant influence. Generalization of these findings is limited because of the individual differences found, but more importantly these differences make understanding cost influences very difficult and complex. The diversity of the findings within sub-dimensions and dimensions as well as within groups makes generalization of specific findings difficult. This means that project managers need to carefully consider their assessments of what influences project costs in their organizations when understanding estimates. This supports the validity of "calibration" as described in Chapter 2.

Revised Year 2000 Enterprise Cost Model

In the Revised Year 2000 Enterprise Cost Model, shown in Figure 3, the primary difference is that the relationships are described at the sub-dimension level rather than the dimension. Although the factor analyses used for measurement validation indicated that the variables aligned to some degree with the dimensions of the model, stronger support was indicated at the sub-dimension level. The relationships may sometimes, in fact, be at the individual attribute level but for simplicity the model includes only sub-dimensions. Furthermore, there are probably additional interactions, such as problem influencing solution as described above that are not indicated in the original or the revised model.

Figure 3. Revised Year 2000 Enterprise Cost Model



Limitations Of This Research

A recognized limitation of survey research is the subjective nature of the data collected. A survey solicits perceptions of the respondents rather than objective observations, and it should be recognized that there might be an unknown bias in the responses. Another limitation is recognition of instrumentation bias. Although the survey was developed by IS professionals and has been reviewed and pilot tested, it has not been extensively used nor tested with multiple datasets over time.

Along with the limitation that the survey solicits perceptions of the respondents, the survey solicited estimated costs rather than actual costs since projects were still in progress. A justification for this research was that there is low credibility for the cost estimates given by IS project managers, and thus there is an inferred low credibility for the estimates reported by these respondents.

Measures for some attributes of the dimensions of the model were general or lacking entirely in the survey. The questionnaire items for complexity and solution particularly do not provide valid measures for these constructs. Although questions were added to ask respondents what they included in their year 2000 estimated costs, there was no simple way to use their responses given the design of the research. Likewise, the measures for solutions probably do not adequately assess the solution dimension. Most of the questionnaire items validated to measure the solution dimension concern progress on one aspect of a solution rather the types of solution selected.

Given the diversity of the findings for the five analysis groups, a limitation of the study is also that the Y2K projects are not as similar as initially thought. The analysis was moderated for size and project stage but not for both simultaneously. More generally, perhaps, is that organizations may not be as similar as initially thought.

Although this research was restricted to exploration of rational cost estimating models, there is evidence, particularly the findings concerning the negative influence for top management support, that political models may be actively influencing the cost estimating relationships. The reluctance of top managers to acknowledge and initiate Y2K projects (Kappelman, 1996, Kappelman & Cappel, 1996, deJager and Bergeon, 1997, Ulrich & Hayres, 1997) may have created situations where the biases and the influences of the stakeholders, primarily top management and the projects managers, exert stronger influences than do project attributes, at least in the early stages of projects.

The internal validity issue of using many statistical tests rather than fewer ones is another limitation of this research. This limitation is only acceptable in exploratory research and somewhat restricts generalization of these findings. The purpose of the examination was to learn as much as possible about the individual detailed relationships of the items within a dimension, but these findings cannot be generalized to make strong representations about the dimension itself.

Further Research

Although this study was exploratory in nature and does have the recognized limitations of survey research, there is weak evidence to reject four of the five null hypotheses. The limited number of significant relationships indicated and the low magnitude of their correlations suggests that further research is required to better understand these relationships. The Year 2000 Enterprise Cost Model was developed from the Process Model for Estimating Costs for an IS Project (Figure 1 in Chapter 1) and has a fundamental link with the relationships that are the basis for all rational cost estimating models. Empirical research using actual cost estimates for projects that have been completed would enable the researchers to explore the relationship of estimated and actual costs with these independent variables as well as with each other.

The significance of this research may not be so much the relationships that were found as the relationships that were not found. The process of calibrating a cost estimate for a specific project in a specific organization is based on understanding these cost influence relationships and their impact on estimated cost. Absence of strong evidence for support of the relationships of the Year 2000 Enterprise Cost Model may indicated the need for more complex models to better understand the cost influence relationships in IS projects.

A review of the literature for empirical research on cost estimating suggests that it usually focuses on the cost-estimating method or compares estimating methods. Little research has been done on the cost influence relationships themselves; yet, in most cost-estimating models, the basis of the calibration process is the knowledge of how these relationships influence estimated cost. At the lowest level, these relationships are organization specific and based on the historical data from prior projects. This research indicated that there might be some cost influence relationships that are worthy of further investigation at a group level, particularly the differences in the relationships at various stages of project completion.

Political models are discounted as ineffective (Grover et al., 1988) but this study suggests that political factors may play a significant role in cost estimates, particularly in the case of high impact projects such as year 2000 compliance projects. The negative relationships found among the independent variables representing top manager support and estimated percent cost indicated possible support for both types of political models described in Chapter 2, estimating based on the biases and influences of stakeholders and estimating based on price-to-win strategies. Understanding cost influence relationships for IS projects is fundamental for successfully predicting the costs of proposed projects and for managing project within budgets once costs are estimated. As the complexity of projects increase and projects interface and link with many other projects inside and outside the organization, the political influences on these projects may become more complex also.

APPENDIX A.

Year 2000 Survey

SIM Society for Information Management
International

Year 2000 Date Problem Study (1997): Instructions

1. Your responses will be kept anonymous. Only the University of North Texas researchers will ever see individual forms and only group summaries will be reported to anyone.
2. This questionnaire should be completed by the person in charge of the year 2000 project in your organization, i.e., the year 2000 project manager. When finished, please put this questionnaire in the pre-addressed, pre-paid, business reply envelope and mail it. THANK YOU FOR YOUR PARTICIPATION!!
3. There are no right or wrong answers. We just need your honest opinions.
4. The questions are grouped into 4 sections concerning your organization, yourself, the Information Systems (IS) group in your organization, and the year 2000 date problem in your organization.
5. Sometimes, a scale of 0 to 9 is provided to record your answer. Please select the ONE answer that best describes your response to the statement provided. Mark 0 if the question is not applicable (NA) or you don't know the answer. Think of the scale from 1 to 9 as a continuum from total disagreement (TD) to total agreement (TA) with the statement provided. For a neutral (N) response, mark 5.

NA =	0	=	This question is <u>not applicable</u> or I don't know the answer.
TD	1	=	<u>totally disagree</u>
	2	=	strongly disagree
	3	=	disagree
	4	=	disagree somewhat
N =	5	=	<u>neutral</u> (neither agree nor disagree)
	6	=	somewhat agree
	7	=	agree
	8	=	strongly agree
TA =	9	=	<u>totally agree</u>

6. Examples: Please complete the survey form as follows:

   a. Clearly mark your answers with a dark pen or marker using the scale of 0 to 9.

	NA	TD				N				TA
We have completely solved our year 2000 problem.	(0)	(1)	(2)	X	(4)	(5)	(6)	(7)	(8)	(9)

   b. Please fill in your answer in any blank spaces provided.

   How many years has your company been in operation? (Please write in your answer.)

   ☐75 years

   c. Please mark the <u>one</u> answer that best describes your parent organization.

   ☐ **(A)** **Publicly-traded company**
   ☐ **(B)** **Privately-held company**
   X **(C)** Other: NON-PROFIT (RELIGIOUS)

7. Please use the following definitions when referring to the "levels" or "subunits" within your organization:

   Area: The functional group within which you work. For example, the Information Systems Department.

   Division: The division level is not present in all organizations. Divisions are distinct, standalone units. For example, Chevrolet is a strategic business unit within the larger company General Motors (GM). In governments (local, state, and federal), these are often called "departments" or "agencies," such as the Commerce Department is to the US Government.

   Parent: The parent organization is the larger entity of which your division is a part. For example, the US Government is the parent of the Commerce Department and GM is the parent of Chevrolet. When the divisional subunit is not present, there is only the parent and its areas.

8. Please use the following definitions when referring to the "year 2000 problem."

   Year 2000 problem: Problems that may result from the inability of computer-based systems to handle dates that span 2 or more centuries, particularly the 20th and 21st.

   Year 2000 compliance: Computer-based systems that can handle dates that span 2 or more centuries without any problems.

   Year 2000 compliance project: A project to repair and/or replace systems that are not year 2000 compliant and to test and verify that all computer-based systems are compliant.

9. Your time and cooperation are sincerely appreciated. If you have any questions or concerns or comments about this survey, or would like any additional information, please contact:

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Associate Professor, Business Computer Information Systems
Associate Director, Center for Quality and Productivity
College of Business Administration, University of North Texas
Box 305249, Denton, Texas 76203
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10. This project has been reviewed and approved by the University of North Texas Committee for the Protection of Human Subjects (940-565-3940) who asked us to tell you that you may withdraw from the experiment at any time without penalty, prejudice, or loss of benefits.

Section 1: ***Please answer the following questions about the organization in which you work: See page 2 of the instructions (item 7) for a definition of the terms "parent" and division."***

1. Please mark the answer that best describes your parent organization. (Mark only one).

Profit-making corporation:
- ☐ (A) Publicly-traded company
- ☐ (B) Privately-held company
- ☐ (C) Other: ______________________

Governmental organization:
- ☐ (D) Federal
- ☐ (E) State
- ☐ (F) County
- ☐ (G) Municipal
- ☐ (H) Other: ______________________

Not-for-profit organization:
- ☐ (I) Educational
- ☐ (J) Religious
- ☐ (K) Philanthropic Foundation
- ☐ (L) Charitable Institution
- ☐ (M) Other: ______________________

☐ *(N) Other:* ______________________

2. Do you work for a division or other part of a parent organization?

☐ No. If no, please go to question number 3.
☐ Yes. If yes, please answer the following for your division

2a. How many **people** work in your division (NOT the functional area in which you work).
(Please write in your answer.)

☐☐☐,☐☐☐,☐☐☐ people

2b. What were the **gross revenues or income** of your division in the last fiscal year?
(Please write in your answer in US dollars.)

☐,☐☐☐,☐☐☐,☐☐☐,☐☐☐.00 in US dollars

2c. Please mark the one answer that best describes the industry of your division.

☐ (A) Agriculture	☐ (L) Insurance
☐ (B) Mining	☐ (M) Real Estate
☐ (C) Construction	☐ (N) Hotels and Leisure
☐ (D) Printing Publishing	☐ (O) Business Services
☐ (E) Transportation	☐ (P) Entertainment
☐ (F) Consumer Goods Manufacturing	☐ (Q) Health
☐ (G) Capital Goods Manufacturing	☐ (R) Legal
☐ (H) Utilities	☐ (S) Education
☐ (I) Retail	☐ (T) Government
☐ (J) Food Service	☐ (U) Military
☐ (K) Banking, Securities, Investments	☐ (V) Other ______________

3. Please answer the following for your parent organization

3a. How many people work for your parent organization? (Please write in your answer.)

☐☐☐,☐☐☐,☐☐☐ people

3b. What were the gross revenues or income of your parent organization in the last fiscal year? (Please write in your answer in US dollars.)

☐☐,☐☐☐,☐☐☐,☐☐☐,☐☐☐.00 in US dollars

3c. Please mark the one answer that best describes the industry of your parent organization.

- ☐ (A) Agriculture
- ☐ (B) Mining
- ☐ (C) Construction
- ☐ (D) Printing Publishing
- ☐ (E) Transportation
- ☐ (F) Consumer Goods Manufacturing
- ☐ (G) Capital Goods Manufacturing
- ☐ (H) Utilities
- ☐ (I) Retail
- ☐ (J) Food Service
- ☐ (K) Banking, Securities, Investments
- ☐ (L) Insurance
- ☐ (M) Real Estate
- ☐ (N) Hotels and Leisure
- ☐ (O) Business Services
- ☐ (P) Entertainment
- ☐ (Q) Health
- ☐ (R) Legal
- ☐ (S) Education
- ☐ (T) Government
- ☐ (U) Military
- ☐ (V) Other ____________________

Section 2: Please answer the following <u>questions about yourself</u>:

1. Did you participate in the SIM year 2000 study last year and complete the questionnaire?

☐ yes ☐ no

2. What is <u>your job title</u>? (Mark only <u>one</u>)

☐ (A) Chief Information Officer (CIO)
☐ (B) Vice President of ____________________
☐ (C) Member of the Board
☐ (D) Director of ____________________
☐ (E) Manager of ____________________
☐ (F) Other ____________________

3. What is the job title of the <u>person you report to</u>? (Mark only <u>one</u>)

☐ (A) Chairman of the Board
☐ (B) Chief Executive Officer (CEO)
☐ (C) Agency Director/Secretary/Administrator
☐ (D) Agency Deputy Director/Agency Under Secretary/ Agency Deputy Administrator
☐ (E) Chief Information Officer (CIO)
☐ (F) Chief Operating Officer (COO)
☐ (G) Chief Financial Officer (CFO)
☐ (H) Controller
☐ (I) Head of Audit Committee
☐ (J) President
☐ (K) President of ____________________
☐ (L) Vice-president of ____________________
☐ (M) Member of the Board
☐ (N) Other ____________________

4. What is <u>your age</u> in years? (Please write in your answer.) ☐☐ years

5. What is your <u>gender</u>? (Mark only <u>one</u>)

☐ Female ☐Male

6. <u>How many years</u> have you been <u>with this parent organization</u>? (Please write in your answer.)

☐☐ years

7. <u>How many years</u> have you held <u>your present position</u>? (Please write in your answer.)

☐☐ years

8. How much formal education do you have? (Mark only one)

- ☐ (A) Did not complete high school.
- ☐ (B) High school graduate.
- ☐ (C) Some college but no degree.
- ☐ (D) 2 year college degree (e.g., AA, AS).
- ☐ (E) 4 year college degree (e.g., BA, BS, BBA)
- ☐ (F) Some graduate school but no degree.
- ☐ (G) A graduate degree (e.g., MBA, MS, MA, PhD, MD).
- ☐ (H) Other ______________________

9. As the person in charge of a year 2000 computer date compliance project in your organization:

9a. How did you come to have this assignment? (Mark only one)
- ☐ (A) Volunteered
- ☐ (B) Assigned or appointed
- ☐ (C) Don't know
- ☐ (D) Other ______________________________
- ☐ (E) I am not the person in charge of the project.

9b. What percentage of your work time is dedicated to this project? (Please write in your answer.)

☐☐☐ %

9c. For how many months have you had this assignment? (Please write in your answer.)

☐☐☐ months

9d. Is the year 2000 project you manage at the parent or division level? (Please mark only one and then please answer at this same level for all of the remaining questions in this questionnaire about your organization's IS organization and its year 2000 compliance project.)

- ☐ (A) Parent
- ☐ (B) Division

Instructions: Please mark the ONE answer that best describes your response to each of the following statements. Select 0 if the question is not applicable (NA) or you don't know the answer. Think of the scale from 1 to 9 as a continuum from total disagreement (TD) to total agreement (TA) with the statement provided. For a neutral (N) response, select 5. See a complete description of the scale on page 1 under item 5.

NA	=	0	=	This question is not applicable or I don't know the answer.
TD	=	1	=	totally disagree
N	=	5	=	neutral (neither agree nor disagree)
TA	=	9	=	totally agree

	NA	TD				N				TA
9e. This assignment as year 2000 project manager is an excellent career-enhancing opportunity for me.	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
9f. I have extensive project management experience with:										
(1) information systems development projects.	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(2) projects that involve many separate application systems.	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(3) projects that involve many separate business units (for example, divisions or areas).	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(4) application maintenance projects.	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)

6

Section 3: ***Please answer the following questions about your Information Systems (IS) organization.***

For all of the questions in this section, please answer for either the parent IS organization or the divisional IS organization (the same level you reported in question 9d in Section 2) concerning your responsibility for managing the year 2000 project. By "IS organization" we mean the functional group (or area) that manages the information assets of some larger organization. By "information assets" we mean the various applications, other software, hardware, networks, data, voice, video, and other assets typically managed by IS professionals working together in some functional unit (i.e., an IS organization).

1. What was the total operating budget of this IS organization during the last fiscal year? This includes all money spent providing information services -- people, communications, hardware, software, maintenance, outsourcing contracts, and any other directly-related items. (Please write in your answer in US dollars.)

   ☐☐,☐☐☐,☐☐☐,☐☐☐.00 US dollars

2. What percentage of this total operating budget was paid to IS outsourcers, consultants, and/or contract people? (Please write in your answer.)

   ☐☐☐%

3. How many people work for this IS organization? (Please include all IS professionals and staff, as well as both direct and dotted-line reports. Do NOT include outsourced, consultants, or contract people.) (Please write in your answer.)

   ☐☐☐,☐☐☐ people

4. How many full-time equivalent outsourced, consultants, or contracted people are employed by this IS organization? (Please write in your answer.)

   ☐☐☐,☐☐☐ people

5. How many levels below the highest manager/executive in your organization does the top information systems manager/executive (CIO) report? (Please mark just one.)

   ☐ (A) CIO is highest manager/executive (0 levels)
   ☐ (B) CIO reports directly to the highest manager/executive (1 level)
   ☐ (C) CIO reports to someone who reports directly to the highest manager/executive (2 levels)
   ☐ (D) 3 levels
   ☐ (E) 4 levels
   ☐ (F) 5 or more levels

Instructions: For each of the following statements, please mark the ONE answer that best describes your response. Select 0 if the question is not applicable (NA) or you don't know the answer. Think of the scale from 1 to 9 as a continuum from total disagreement (TD) to total agreement (TA) with the statement provided. For a neutral (N) response, select 5. Refer to page 1 for a complete description of the scale.

NA = 0 = This question is not applicable or I don't know the answer
TD = 1 = totally disagree
N = 5 = neutral (neither agree nor disagree)
TA = 9 = totally agree

6. This IS organization:	NA TD N TA
6a. has a comprehensive and tested IS disaster recovery plan.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
6b. does extensive benchmarking to other IS organizations.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
6c. has a clearly defined and utilized software process methodology for:	
(1) IS development.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
(2) application maintenance (i.e., minor changes).	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
(3) system conversion (i.e., large scale changes).	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
(4) change management (keeping track of versions, maintenance, and conversions)	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9).
6d. encourages project managers to recommend that software projects be terminated if they deserve to be.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
6e. encourages everyone on a project team to recommend that software projects be terminated if they deserve to be.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
6f. assigns those who develop programs the responsibility for maintaining them throughout their entire life cycle.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
6g. Cost estimating for IS projects is based primarily on:	
6g-1. these metrics:	
(1) number of lines of code	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
(2) function points	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
(3) other ________________	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
6g-2. these estimating methods:	
(1) Top-down	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
(2) Bottom-up	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
(3) Historical data	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
(4) A combination of these	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
6h. This IS organization aspires to the software development practices of the Software Engineering Institute's (SEI's) Configuration Maturity Model (CMM) (as per Watts Humphrey and Mark Paulk)	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)

6i. If your IS organization does aspire to SEI CMM practices, at what level would your IS organization be assessed? (Please mark only one.)

- ☐ (1) Initial (level 1)
- ☐ (2) Repeatable (level 2)
- ☐ (3) Defined (level 3)
- ☐ (4) Managed (level 4)
- ☐ (5) Optimizing (level 5)

7. For software development and/or maintenance this IS organization specifies and uses a comprehensive set of processes and/or procedures for:

		NA	TD				N				TA
7a.	establishing customer agreement on requirements.	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
7b.	estimating all resource needs.	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
7c.	tracking progress and resource use.	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
7d.	selecting, contracting, tracking, and reviewing software contractors/outsourcers.	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
7e.	software quality assurance.	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
7f.	continuous process improvement.	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
7g.	identifying the training needs of IS professionals.	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
7h.	tailoring the process to project-specific needs.	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
7i.	coordination and communication among development groups.	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
7j.	the examination of work products by peers.	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
7k.	measuring project progress.	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
7l.	establishing quality goals with customers.	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
7m.	analyzing problems and preventing re-occurrence.	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
7n.	evaluating new technologies and utilizing when appropriate.	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
7o.	continuous productivity improvements.	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
7p.	unit, system, acceptance, and regression testing.	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)

Section 4: ***Please answer the following questions about the "year 2000 date problem." By the "year 2000 date problem" we are referring to problems that may result from the inability of computer-based systems to handle dates that span 2 or more centuries, particularly the 20th and 21st. Systems that can handle such dates are said to be "year 2000 date compliant" or "century compliant."***

For all of the questions in this section, please answer for either the parent IS organization or the divisional IS organization (the same level you reported in question 9d in Section 2) concerning your responsibility for managing the year 2000 project. This is the same organizational level you answered for in Section 3.

Instructions: Please select the ONE answer that best describes your response to each of the following statements. Select 0 if the question is not applicable (NA) or you don't know the answer. Think of the scale from 1 to 9 as a continuum from total disagreement (TD) to total agreement (TA) with the statement provided. For a neutral (N) response, select 5. Refer to page 1 for a complete description of the scale.

NA	=	0	=	This question is not applicable or I don't know the answer.
TD	=	1	=	totally disagree
N	=	5	=	neutral (neither agree nor disagree)
TD	=	9	=	totally agree

	NA TD N TA
1. I have discussed the year 2000 date problem extensively:	
1a. with the chief executive of my organization.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
1b. with the person I report to.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
1c. with those who report to me.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
1d. with the internal auditors of my organization..	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
1e. with the highest level executive council (e.g., board or directors) of my organization.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
1f. with the legal department of my organization.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
1g. with division, department, agency, or area managers in my organization.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
1h. with my peers in my organization.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
2. Regarding the year 2000 date problem in my organization:	
2a. I closely follow this issue in the media.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
2b. I regularly attend workshops or conferences about this.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
2c. This situation is the result of a terrible mistake.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
2d. This situation is the result of changed circumstances and other matters that could not have reasonably been anticipated.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
2e. It will significantly impact our competitive advantage.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
2f. It will significantly impact our ability to serve our customers/citizens.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
2g. Solving this has the highest priority in my organization.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
2h. This is not a serious problem in this organization.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
2i. We are solving the year 2000 date problem as part of a larger IS development and/or enhancement project.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
2j. We have centralized control of all year 2000 date efforts.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)

2. Regarding the year 2000 date problem in my organization: (continued)

	NA TD N TA
2k. All of the functional areas and divisions (if applicable) are working closely together to solve this problem.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
2l. I am very confident that we will be year 2000 date compliant with time to spare.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
2m. I am very confident that we will become year 2000 date compliant within the amount of moneys budgeted.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
2n. The year 2000 date problem will have no impact whatsoever on this organization.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
2o. This problem as been included on the meeting agenda(s) of the audit committee of the board of directors (or other top executive governing board) during the past year.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
2p. Someone should be held responsible for causing this situation.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)

3. This organization:

3a. is well aware of the year 2000 date problem.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
3b. has studied the year 2000 date problem, inventoried its applications, and conducted an impact analysis.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
3c. takes year 2000 date compliance into consideration in all new outsourcing and contracting agreements.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
3d. takes year 2000 date compliance into consideration in all new licensing agreements.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
3e. has year 2000 date compliance covered in all existing outsourcing and contracting agreements.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
3f. has year 2000 date compliance covered in all existing licensing agreements.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
3g. has established standards for year 2000 date compliance.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
3h. has detailed plans, schedules, and budgets for solving the year 2000 date problem.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
3i. has conducted pilots to validate its year 2000 budget estimates	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
3j. has already solved the year 2000 problem at the code and data level.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
3k. has already tested its year 2000 date compliance solution(s).	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
3l. has implemented and made operational its solution(s) to the year 2000 date problem.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
3m. has already solved the problem and is year 2000 date compliant.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
3n. will implement (or has already implemented) a ________	
3n-1. 100% date field expansion.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
3n-2. 100% logic-only and/or windowing solution to the year 2000 date problem.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
3n-3. hybrid solution involving both of these approaches to the year 2000 date problem.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
3o. has had significant discussions of the year 2000 date problem with its ________:	
3o-1. customers.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
3o-2. suppliers.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
3o-3. internal users.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
3o-4. trading partners.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
3o-5. software and hardware	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)

3. <u>This organization:</u> (continued)

	NA	TD				N				TA
3p. has organization-wide definitions and standards for year 2000 date compliance.	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
3q. will extensively rely on ____________ for external help with year 2000 date problem solutions.										
3q-1. outsourcing and contractors	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
3q-2. offshore programmers	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
3q-3. consultants	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
3q-4. vendor's tools	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
3r. is aware of the year 2000 date problem and will solve it later.	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
3s. expects to have a significant amount of hardware replacements and/or upgrades in solving the year 2000 date problem.	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
3t. has conducted a business risk assessment in order to uncover any year 2000 exposure.	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
3v. has prioritized projects according to the findings of business risk assessment.	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
3w has curtailed spending on other projects to provide resources for a year 2000 project.	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
3x. has completed an inventory of all hardware, software, and data assets.	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
3y. has completed an impact study to determine the exact nature of our year 2000 problem on all hardware, software, and data assets.	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
3z. is finding totally adequate capacity and availability of:										
3z-1. outsourcing and contractors	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
3z-2. offshore programmers	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
3z-3. consultants	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
3z-4. vendor's tools	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)

4. The person in charge of solving the year 2000 date problem in your organization reports to ____________ (Mark one):

☐ (A) Me.
☐ (B) I am the person in charge.
☐ (C) CFO (top financial manager/executive)
☐ (D) CIO (top IS manager/executive)
☐ (E) CEO (top manager/executive)
☐ (F) Head of Internal Audit
☐ (G) Controller
☐ (H) Outside consultant or vendor
☐ (I) Don't know.
☐ (J) No one is in charge of this.
☐ (K) Other ______________________________

5. <u>How</u> will year 2000 date <u>compliance be funded</u>? (Mark <u>all</u> that apply)

☐ (A) Regular IS development budget
☐ (B) Regular IS maintenance budget
☐ (C) Special project budget
☐ (D) Special organization-wide budget for year 2000 compliance
☐ (E) Business units
☐ (F) Project level
☐ (G) Don't know
☐ (H) Other ___________________________

6. <u>What is your best estimate of how much it will cost</u> to make your organization's information systems year 2000 date compliant? (Please write in your answer in US dollars.)

□□,□□□,□□□,□□□.00 US dollars

6a. If you are calculating your cost or paying a cost based on a line of code amount, how much per line are you paying? (Please write in your answer in US dollars.)

□□□.□□ per line of code in US dollars

6b. The estimate includes all considerations of:

		NA	TD				N				TA
6b-1.	Software	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
6b-2.	Hardware	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
6b-3.	People	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
6b-4.	Outsourcing contracts	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
6b-5.	Testing library improvements	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
6b-6.	Data repairs	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
6b-7.	Project management	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
6b-8.	Other ______________________	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)

7. <u>When</u> will your organization <u>be finished</u> solving the year 2000 date problem?

□ (A) Compliant before 1996
□ (B) 1996
□ (C) 1997
□ (D) 1998
□ (E) 1999
□ (F) 2000
□ (G) Don't know
□ (H) Never
□ (I) Other ____________________

8. <u>Where</u> in your organization <u>is primary responsibility for</u> the year 2000 date compliance effort? (Mark <u>all that apply</u>.)

□ (A) IS group / area / function
□ (B) Corporate / organization's highest level / parent
□ (C) Division / business units / agency level
□ (D) Area / function level
□ (E) Specific team is responsible
□ (F) Consultants
□ (G) Vendor
□ (H) The audit department
□ (I) Don't know
□ (J) The buck stops here with me.
□ (K) Other ____________________

9. How do you plan to handle year 2000 date compliance for systems the IS department does not control (e.g., a user-developed spreadsheet that uses dates for calculations)? (Mark <u>all</u> that apply)

□ (A) Do nothing
□ (B) IS Department fixes everything
□ (C) Make users aware of problem
□ (D) Offer users support and consulting services
□ (E) Undecided
□ (F) Don't know
□ (G) Other ________________________

10. Please write in your best estimate of the correct amount to answer the following questions (do not include desktop systems or multiple copies of the same program or file, but do include server-based applications). If you don't know, please mark that answer.

10a. How many total lines of code (in thousands) are in your organization?

☐☐,☐☐☐,☐☐☐,000 lines of code ☐ I don't know

10b. How many software applications are in your organization?

☐☐,☐☐☐,☐☐☐ applications ☐ I don't know

10c. How many separate data files are in your organization?

☐☐,☐☐☐,☐☐☐ files ☐ I don't know

10d. How much total disk storage (in gigabytes) is in your organization?

☐☐,☐☐☐,☐☐☐ gigabytes ☐ I don't know

10e. How many total function points are in your organization?

☐☐,☐☐☐,☐☐☐ function points ☐ I don't know

11. Please write in your best estimate of the correct **percentage** to answer the following questions (do not include desktop systems or multiple copies of the same program or file, but do include server-based applications). If you don't know, please mark that answer.

In achieving year 2000 date compliance what percent of all of the:

11a. lines of code in your organization is affected? ☐☐☐ % of lines ☐ I don't know

11b. applications in your organization is affected? ☐☐☐ % of applications ☐ I don't know

11c. applications do you plan to replace? ☐☐☐ % to replace ☐ I don't know

11d. applications do you plan to modify? ☐☐☐ % to modify ☐ I don't know

11e. data files do you plan to modify? ☐☐☐ % of files ☐ I don't know

11f. screens and reports do you plan to modify? ☐☐☐ % of screens/reports ☐ I don't know

14

11g. source code do you believe to be missing? ☐☐☐ % of source code

☐ I don't know

11h. hardware will need to be upgraded or replaced? ☐☐☐ % of hardware

☐ I don't know

11i. system software and utilities will need to be upgraded or replaced?

☐☐☐ % of system software

☐ I don't know

Instructions: Please select the ONE answer that best describes your response to each of the following statements. Refer to page 1 for a complete description of the scale.

NA = 0 = This question is not applicable or I don't know the answer.
TD = 1 = totally disagree
N = 5 = neutral (neither agree nor disagree)
TA = 9 = totally agree

	NA TD	N	TA
12. As year 2000 project manager, I have completely adequate ________ to get the job done.			
12b. authority	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)		
12b. money	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)		
12c. human resources	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)		
12d. management support	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)		
12e. hardware capabilities	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)		
12f. time	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)		
13. The functional areas and divisions (if applicable) are making progress at the same pace and in unison.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)		
14. The electronic data interchange (EDI) standards used by my organization are totally year 2000 date compliant.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)		
15. I expect absolutely no operating system (client-, server-, or communications-related) or middleware issues or problems?	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)		
16. This organization has begun development of test plans.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)		
17. Year 2000 compliance tests will be extensive for all applications.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)		

18. The year 2000 project team that is responsible for process control systems (embedded systems and firmware applications like elevators, security systems, heating/cooling systems, manufacturing) will ________________:

18a. modify process control systems	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
18b. certify process control systems	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
18c jointly work together with process control system users	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
18d raise awareness of process control system users	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)

19.	This organization will have a centralized group to:	NA TD N TA
19a.	certify all applications	(0) (1) (2) (3) (4) (5) (6) (7) (8)(9)
19b.	certify all purchased application	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
19c.	certify all utility software products	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
19e.	certify all replaced applications.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
19d.	We will not certify any applications/products.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
20.	Hardware capacity is very adequate for compliance testing.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
21.	The organization has adequate test facilities:	
21a.	For mainframe applications and products.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
21b.	For midrange applications and products	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
21c.	For microcomputer applications and products.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
22.	The people assigned to our year 2000 project team are extremely well experienced at software maintenance.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
23.	The <u>expertise</u> of our year 2000 project team is <u>totally adequate</u> in the following areas:	
23a.	Analysis	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
23b.	Logical design	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
23c.	Standard setting	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
23d.	Coding / programming	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
23e.	Data conversion	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
23f.	Data administration / database management	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
23g.	Testing	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
23h.	Software change management (e.g., version control)	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
23i.	Project management	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
23j.	Software process methodology	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
23k.	interfacing or linking applications together	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
23l	Software quality assurance	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
23m	Setting priorities and planning	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
23n.	Contingency planning	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
23n.	Risk management	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
24.	Attrition and turnover of year 2000 project team members will not be a significant problem at all.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
25.	A bonus will be paid to all year 2000 team members who stay with the project to its successful completion.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
26.	The year 2000 date problem will have a significantly negative effect on my organization.	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
27.	<u>Top IS management</u> ___________ the year 2000 date problem.	
27a.	strongly supports and is committed to solving	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
27b.	really understands the scope (how big it is) of	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
27c.	really understands the potential impact (how serious it is)	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
28.	<u>Top organizational management</u> ___________ the year 2000 date problem.	
28a.	strongly supports and is committed to solving	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
28b.	really understands the scope (how big it is) of	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)
28c.	really understands the potential impact (how serious it is) of	(0) (1) (2) (3) (4) (5) (6) (7) (8) (9)

29. Describe how you report year 2000 progress to management.

	NA	TD				N				TA
29a. Report by number or percent of applications/products/programs completed.	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
29b. Report by number or percent of function points completed.	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
29c. Report by number or percent of lines of code modified.	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
29d. Management does not want a report.	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)

30. The variety of computer languages will be a major factor in becoming year 2000 compliant. (0) (1) (2) (3) (4) (5) (6) (7) (8) (9)

31. Systems integration is a very significant issue in resolving the year 2000 date problem. (0) (1) (2) (3) (4) (5) (6) (7) (8) (9)

32. I expect no downtime of systems during installation and deployment of year 2000 modifications. (0) (1) (2) (3) (4) (5) (6) (7) (8) (9)

33. Computer-based tools will play a significant role in:

33a. determining scope of problem and inventorying applications.	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
33b. conducting impact assessment	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
33c. storing and managing inventory and impact data (i.e. data repository tools)	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
33d. planning, scheduling, budgeting, and prioritizing	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
33e. converting and/or replacing code	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
33f. testing the solution	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
33f. change management (i.e., version control)	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
33g. estimating cost	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
33h. modifying data	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)

34. Please write in the (1) correct percentage of total year 2000 compliance project time that you plan to spend, on each activity and (2) the estimated percent of each activity completed to date. (The total of the 5 answers for correct percentage of this activity [column 1] should = 100%.) If you don't know, please mark that answer.

		(1) % of Time	(2) % Completed
34a. Determining scope of problem, inventorying applications, conducting impact assessment:		☐☐☐	☐☐☐
	I don't know	☐	☐
34b. Planning, scheduling, budgeting, and prioritizing:		☐☐☐	☐☐☐
	I don't know	☐	☐
34c. Converting and/or replacing code, modifying data, replacing hardware:		☐☐☐	☐☐☐
	I don't know	☐	☐
34d. Testing the solution		☐☐☐	☐☐☐
	I don't know	☐	☐
34e. Making the solution operational:		☐☐☐	☐☐☐
	I don't know	☐	☐
	Total:	**100%**	

35. Please write in the correct percentage of total year 2000 compliance project money that you plan to spend within each of the following activities? If you don't know, please select that response. (The total of these 6 answers should = 100%.)

35a. Determining scope of problem, inventorying applications, conducting impact assessment:	☐☐☐%	☐ I don't know
35b. Planning, scheduling, budgeting, and prioritizing:	☐☐☐%	☐ I don't know
35c. Converting and/or replacing code and modifying data:	☐☐☐%	☐ I don't know
35d. Replacing hardware:	☐☐☐%	☐ I don't know
35e. Testing the solution:	☐☐☐%	☐ I don't know
35f. Making the solution operational:	☐☐☐%	☐ I don't know
Total	**100%**	

36. Please write in what percentage of the total year 2000 date compliance software and hardware problem in your organization resides on each of the following hardware categories (The total of these 3 answers should = 100%.) If you don't know, please mark that answer.

36a. Mainframe:	☐☐☐%	☐ I don't know
36b. Midrange:	☐☐☐%	☐ I don't know
36c. Microcomputer:	☐☐☐%	☐ I don't know
Total	**100 %**	

37. Please write in what percentage of the total year 2000 date compliance problem exists in each of the following software categories? (The total of these 4 answers should = 100%.) If your don't know, please mark that answer.

37a. purchased applications 10 or more years old:	☐☐☐%	☐ I don't know
37b. custom-built applications 10 or more years old:	☐☐☐%	☐ I don't know
37c. purchased applications less than 10 years old:	☐☐☐%	☐ I don't know
37d. custom-built applications less than 10 years old:	☐☐☐%	☐ I don't know
Total	**100%**	

38. Who is the primary executive sponsor for the year 2000 project in your organization? (Mark one.)

☐ (A) CIO
☐ (B) CFO
☐ (C) CEO
☐ (D) Director of ______________________
☐ (E) Manager of ______________________

39. How many levels below the top information systems manager/executive do you report in your organization (CIO)? (Mark one.)

☐ (A) I am the CIO (O levels)
☐ (B) I report directly to the CIO (1 level)
☐ (C) I report to someone who reports directly to the CIO (2 levels)
☐ (D) 3 levels
☐ (E) 4 levels
☐ (F) 5 or more levels

40. What percent of your customers/suppliers are actively addressing their own year 2000 issues?

☐☐☐☐☐☐ % ☐ I don't know

41. On your year 2000 project team, how many ______________________: (Please write in your answer.)

41a. total people are assigned (include contract and outsourced)
☐,☐☐☐,☐☐☐ ☐ I don't know

41b. are contracted and outsourced ☐,☐☐☐,☐☐☐ ☐ I don't know

41c. are full time ☐,☐☐☐,☐☐☐ ☐ I don't know

41d. are users (not-IS professionals) ☐,☐☐☐,☐☐☐ ☐ I don't know

41e. are dedicated to coordinating outsourcers/contractors ☐☐☐,☐☐☐ ☐ I don't know

42. Is there anything else you would like to tell us regarding the year 2000 date problem? For example, lessons have you learned (to date) or important issues that this questionnaire may not have covered.

Please use the space provided below to write your response(s).

Thank you for your time. Please return this completed form immediately using the prepaid business reply envelope.

APPENDIX B.

Letters of Sponsorship

SIM

International

Society for Information Management
401 North Michigan Avenue
Chicago, Illinois 60611-4267 USA
312.644.6610
312.245.1081 (Fax)
info@simnet.org (Email)
www.simnet.org

July 14, 1997

Dear SIM Member:

The SIM Year 2000 Working Group is conducting a new study to ascertain the progress and practices of year 2000 compliance projects in organizations of all kinds. The results of their 1996 study generated considerable interest. The study has been the focus of several journal articles and a book. The book, with articles contributed by many SIM members, is SIM's first and should be available by the end of this month. The Year 2000 Working Group is helping the information technology (IT) community address the year 2000 computer date problem as well as bringing recognition to SIM International as the preeminent organization for IT professionals.

The Working Group needs your assistance with this year's study. Whether or not you participated in last year's study, please participate this year and pass the enclosed envelope on to your organization's year 2000 project manager. This year's survey will focus again on benchmarking the situation and requires input only from the year 2000 project manager in your organization. I personally want to thank you for your support and participation in this timely and important work.

Best Regards,

Steven John
SIM Executive Director

SIM

International

Society for Information Management
401 North Michigan Avenue
Chicago, Illinois 60611-4267 USA
312.644.6610
312.245.1081 (Fax)
info@simnet.org (Email)
www.simnet.org

July 14, 1997

Dear Year 2000 Project Manager:

The SIM Year 2000 Working Group is conducting a study on the year 2000 date compliance issues facing organizations of all kinds. The results of their 1996 study have been published and generated considerable interest. The Working Group needs your assistance with this year's study.

This year's survey will focus on benchmarking the situation and identifying the best practices for becoming year 2000 century date compliant. Whether or not you participated last year, I ask that you please participate in this timely and important work. Only those of you actively managing these projects can provide the answers, and I want to personally thank you for your participation.

The results will be made available to all SIM members and other interested parties.

Best Regards,

Steven John
SIM Executive Director

University of North Texas
College of Business Administration
Department of Business Computer Information Systems

July 21, 1997

SIM International — Society for Information Management

Dear Year 2000 Project Manager:

The Society for Information Management (SIM) through its Year 2000 Working Group is conducting a study to help all IS/IT professionals solve the year 2000 century date problem. The results of their 1996 survey have been published, and it is important that we continue to share ideas and monitor progress in order to deal more effectively with this problem. Whether you participated last year or not, your participation this year will make the results more valuable.

Please complete the enclosed questionnaire and return it to me by August 15th using the postage-paid envelope provided. We realize that completing the survey takes some of your valuable time and thought, but there is no other way to get a complete picture concerning the year 2000 date problem. Your cooperation and assistance are greatly appreciated. As a small expression of our gratitude for your participation in this year's study, if you would like a copy of our "cost of year 2000 compliance" study, please attach your business card to this letter and return it with your completed questionnaire.

Strict confidentiality and anonymity of your responses is guaranteed. Only my research team at the university will see the individual responses. All reports will be in the form of averages or frequency counts. The results will be made available to all year 2000 project managers through SIM and the University of North Texas. If you would like a copy of the results of this year's study, or if I can provide you with any additional information, please let me know. I hope that we can continue to help each other.

Thank you in advance for taking the time to contribute to this important work. I am,
Sincerely yours,

Leon A. Kappelman

Leon A. Kappelman, Associate Professor
Co-chair, SIM Year 2000 Working Group
Associate Director, Center for Quality and Productivity
Email: kapp@unt.edu
Website: www-lan.unt.edu/coba/bcis/faculty/kappelma/

Enclosures: Year 2000 Survey
Postage-paid return envelope
Letter from SIM

P.O. Box 305249 • Denton, Texas 76203-5249
(940) 565-3110 • TDD (800) 735-2989

University of North Texas

College of Business Administration
Department of Business Computer Information Systems

July 21, 1997

SIM
International

Society for
Information
Management

Dear Fellow IS Professional:

I am co-chair of the SIM Year 2000 Working Group and we need your help in helping everyone address the year 2000 computer date problem. The results of our 1996 study established a benchmark of progress toward compliance. As the immutable deadline draws closer, it is important that our work continue in order to help us all more quickly and effectively deal with this problem. Whether or not you participated in last year's study, we need your participation this year.

This year's study targets only the year 2000 project manager in your enterprise. There is another envelope in this packet for the person in your organization who is responsible for managing the year 2000 compliance project.

- ⇒ Please pass this envelope along to the appropriate person in your organization and
- ⇒ ask them to please complete the questionnaire and return it to us by August 15th using the postage-paid envelope provided.

Your support and assistance are greatly appreciated. Strict confidentiality and anonymity of all responses is guaranteed. Only my research team at the university will see individual responses. All reports will be in the form of averages or frequency counts. The results will be made available to all interested parties. If you would like a copy, or if I can provide you with any additional information, please let me know.

Thank you in advance for helping with this important work. I am,
Sincerely yours,

Leon A. Kappelman

Leon A. Kappelman, Associate Professor
Co-chair, SIM Year 2000 Working Group
Associate Director, Center for Quality and Productivity
Email: kapp@unt.edu
Website: www-lan.unt.edu/coba/bcis/faculty/kappelma/

Enclosures: Year 2000 Project Manager Survey Packet

P.O. Box 305249 • Denton, Texas 76203-5249
(940) 565-3110 • TDD (800) 735-2989

APPENDIX C

Follow-up Mailings

We recently mailed you a survey packet, asking that you forward it to the year 2000 project manager in your organization. Please remind the person to whom you forwarded the survey of the importance of sharing the knowledge and experiences gained.

SIM International — Society for Information Management
Year 2000 Working Group

If your organization has already returned the survey, thanks for your support and a special thanks to the year 2000 project manager for the valuable time spent completing the survey.

Attach your business card, and we will send you a copy of the article, “How Much Will Year 2000 Compliance Cost?” This article includes a Year 2000 Enterprise Cost Model that was developed using last year’s survey data.

Offer good only for organizations participating in our study please.

We recently mailed you a survey packet, asking that you forward it to the year 2000 project manager in your organization.

SIM International — Society for Information Management
Year 2000 Working Group

If your organization has already returned the survey, thanks for your support and a ***special thanks*** to the year 2000 project manager for the valuable time spent completing the survey. If your organization has not returned the survey, we have extended the deadline until September 15th to encourage more organizations to participate. Please remind the year 2000 project manager in your organization of the importance of returning the survey.

Attach your business card, and we will send you a copy of the article, “How Much Will Year 2000 Compliance Cost?” This article includes a Year 2000 Enterprise Cost Model that was developed using last year’s survey data.

Offer good only for organizations participating in our study please.

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